ANNEX 1: Literature Review

Contents

Abbreviations

ANCON	Aircraft noise contour
ANN	Artificial neural network
AONB	Area of Outstanding Natural Beauty
AQ	Air quality
AST	Appraisal summary table
BBOP	Business Biodiversity Offset Programme
BEIS	Department for Business, Energy and Industrial Strategy
CBA	Cost Benefit Analysis
CEH	Centre for Ecology and Hydrology
CS	Consumer surplus
DALY	Disability-Adjusted Life Years
DBA	Decibels
DCLG	Department for Communities and Local Government
DECC	Department for Energy and Climate Change
DfT	Department for Transport
DMRB	Design Manual for Roads and Bridges
CEP	Collingwood Environmental Planning
ES	Ecosystem service
ESS	Ecosystem Services
EIA	Environmental Impact Assessment
ELC	European Landscape Convention
EVL	Environmental Value Look-up
FCERM	Flood and coastal erosion risk management
GDP	Gross Domestic Product
GHG	Greenhouse gas
GIS	Geographical Information Systems
GWME	Great Western Mainline Electrification
IGCB	Interdepartmental Group on Costs and Benefits
IMR	Impact Mitigation Regulation
LCM	Land Cover Map
LBAP	Local Biodiversity Action Partnership

LCA	Landscape Character Assessment
LU	London Underground
MAC	Marginal abatement cost
MENE	Monitoring Engagement with the Natural Environment
MRM	Meta-regression models
NAO	National Audit Office
NC	Natural Capital
NCC	Natural Capital Committee
NERC	Natural Environment and Rural Communities
NIC	National Infrastructure Committee
NOx	Oxides of nitrogen
NPV	Net present value
ODPM	Office of the Deputy Prime Minister
OLE	Overhead line electrification
ONS	Office for National Statistics
ORVal	Outdoor Recreation Valuation tool
PES	Payment for ecosystem services
PV	Present value
QALY	Quality-Adjusted Life Years
RP	Revealed preference
RSPB	Royal Society for the Protection of Birds
SP	Stated preference
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
STPR	Standard time preference rate
TEV	Total Economic Value
TfL	Transport for London
TGF	Trip generation function
UKNEA	United Kingdom Natural Ecosystem Assessment
WTA	Willingness to accept
WTP	Willingness to pay
VfM	Value for money
VQI	Visual Quality Index
ZVI	Viewshed

Annex 1. Review of Supporting Evidence

1.1 Landscape Appraisal and WebTAG

This Annex examines the approach to landscape appraisal in WebTAG, including the monetary values used, the context of approaches that can inform economic valuation, such as ecosystem services and natural capital. It also considers how the study outputs could fit into WebTAG, especially use of monetary values through value transfer, and the potential role of primary valuation.

1.2 Coverage of Landscape in WebTAG

In a transport scheme appraisal, landscape is most often included in a value for money assessment as a non-monetised impact, alongside other environmental impacts. WebTAG Unit A3, Section 6 provides guidance on how a non-monetised assessment of these impacts can be undertaken. This approach was developed by the Department for Transport together with Natural England, English Heritage and the Environment Agency.

The WebTAG non-monetised assessment is wide-ranging and covers the impact of proposals on various aspects of landscape that affect the wellbeing of the public. This is combined with an understanding of the local and national importance of the landscape, and its relative rarity and substitutability. It considers different landscape features, their visibility and accessibility, and how they combine to give a landscape its holistic values.

However, landscape professionals regard some aspects of landscape value as intrinsic and originating from a different value construct compared to the instrumental basis for monetary valuation based on welfare economics theories.

As described in Section 2.1 of the main report, the environmental impacts currently covered in the WebTAG guidance include Noise, Air quality, Greenhouse gases, and the Environmental Capital Approach which includes Landscape, Townscape, Historic Environment, Biodiversity and Water Environment.

Within scheme appraisals, monetary values are particularly useful because they can inform trade-offs and resource allocations, within the context of overall value for money guidance for new transport proposals[1]. WebTAG states that "…*where possible, it is preferable for impacts to be measured in monetary values (monetisation)*" (#3.21). At present, monetised impacts are classified as 'established', 'evolving' or 'indicative' and this determines whether they are included within initial or adjusted value for money metrics or considered outside these metrics in terms of the 'switching values' that would be required to alter the value for money categorisation of the investment. In addition, some impacts are deemed to be non-monetised.

As noted in Section 2.1 of the main report, landscape impacts are currently the subject of specific Supplementary VfM Guidance. This sets out the current method for valuing landscape impacts in monetary terms and is a key area of focus of this research project. At present, landscape is deemed to be an indicatively-monetised impact used for value for money purposes, due to uncertainties around the robustness of assessing the impact of transport schemes on landscape and expressing that impact in monetary values, in a generalisable and quick way. The presence of non-monetary

[1] DfT (2017) – Value for Money Framework.

impacts in WebTAG appraisals helps capture non-monetised effects, but reduces the ability to assess trade-offs systematically, therefore putting greater reliance on decision-makers' judgement.

1.3 Landscape Appraisal in WebTAG

The WebTAG-recommended approach to landscape assessment, and the five steps comprising this, are described in Section 2.2 of the main report. This section provides background information on how landscape impacts are classified and assessed.

1.3.1 Classifying Landscape Impacts

Within Landscape Character Assessment (LCA), and therefore landscape appraisal that uses LCA, Landscape perception includes all of the senses. This is illustrated in Figure A1.1, which reproduces Figure 1 of the 2014 LCA Approach (itself directly adapted from the 2002 guidance), and which shows the range of factors generally considered to be part of landscape.

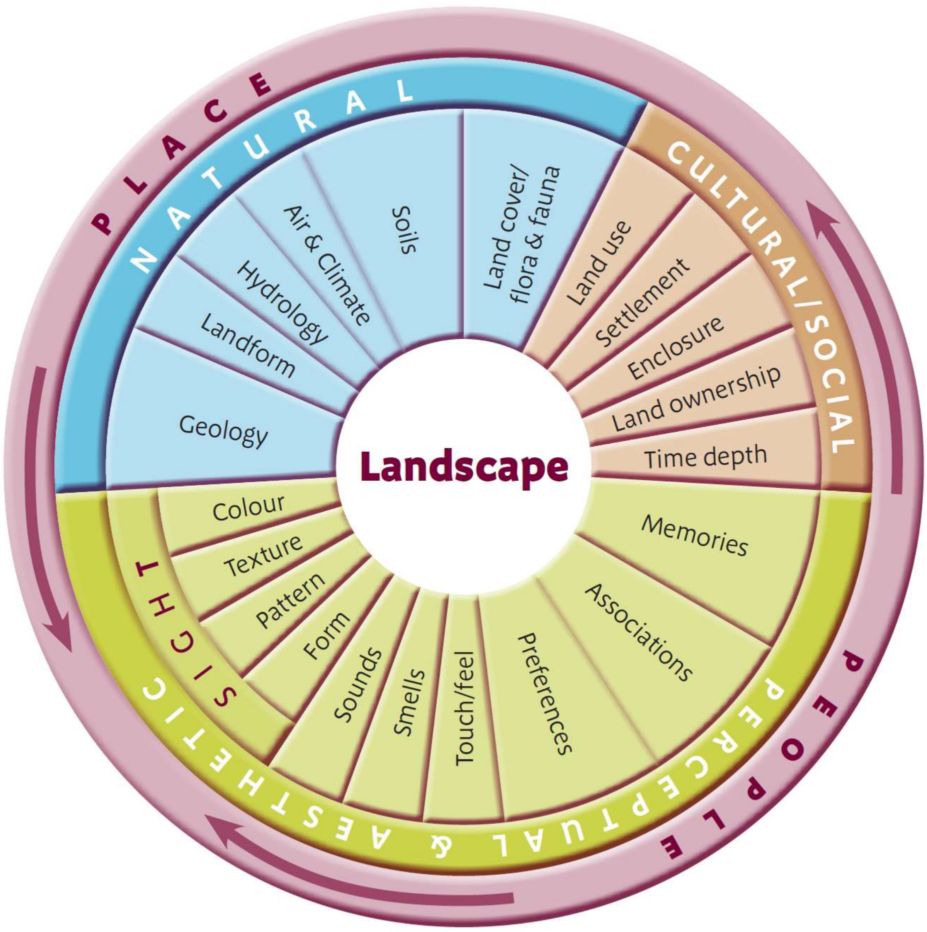


Figure A1.1: Factors Considered Part of Landscape. (Source: Figure 1 of the 2104 LCA Approach.

The wider range of factors shown in Figure A1.1 have some implications for overlaps with WebTAG:

- Aesthetics and smell or air pollution are part of Landscape and should be considered in landscape assessment. This superficially seems to overlap with the assessment of air quality impacts elsewhere in WebTAG. However, air quality assessment is based on the health implications of air pollution, whereas in Landscape category it's about the benefit of cleanliness of air as part of experiencing the landscape. Therefore the risk of double-counting seems low.
- Historic and built environments are also part of Landscape, but similarly are covered elsewhere (under cultural heritage) in WebTAG. In addition, they are not strictly part of natural capital and so we suggest they are omitted from the scope of this project. However, an aspect of cultural heritage is reflected through its contribution to recreation and aesthetic values. It is also relevant to note that historic environment features and natural capital are not completely independent - heritage can contribute to landscape quality, such as where heritage assets (e.g. a Manor House) are linked to natural capital (e.g. hedgerows denoting its agricultural boundaries).

The various terms used to describe landscape value are represented in Figure A1.2 below, showing definitions of 'landscape quality', 'scenic quality' and 'landscape value' and how these concepts are linked.

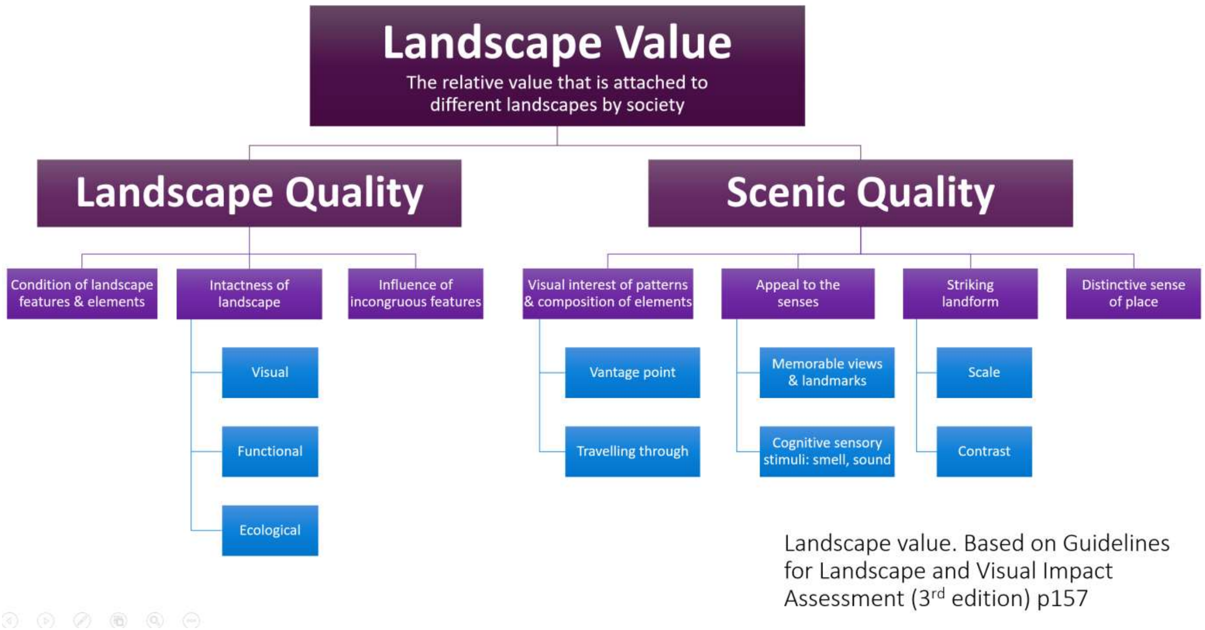


Figure A1.2: Typology of Landscape Value.

'Landscape quality' relates to the condition or physical state of the landscape; 'scenic quality' relates to the pattern or composition of landscape elements within a landscape which appeals to the senses (mainly visual) and; both of these are used, along with other indicators such as tranquillity and natural/cultural heritage, to determine 'landscape value'.

The range of features covered in Landscape Character Assessment and the relationships between type of landscape value make demonstrating consistent appraisal of landscape impacts more difficult. This is compounded by landscape quality not just being a function of the presence of desirable features (e.g. trees, a river, a waterfall), but also (i) their spatial configuration and visibility (which depends on topography/access points/vegetation), and (ii) how important those features are to the character of the landscape in question. For example, a hedgerow has a higher importance in a landscape where the pattern of hedgerows is a key defining feature, such as a valley side landscape than in a landscape where the pattern is less apparent, such as a flat floodplain.

These important features are often described in a Landscape Character Assessment as the key characteristics of the landscape. Projects that have a direct effect on the key characteristics of a landscape have a higher impact than those which affect less prominent features.

1.3.2 Identifying the People Affected by Landscape Impacts

An important part of appraisal is to identify how many people are affected by the landscape impacts of a project and how (through which interaction with the landscape and in which direction – gain or loss). Relevant population depends on the types of benefits (i.e. use and non-use) considered, but should include residents and others enjoying landscape, particularly those engaged in outdoor informal recreation. Those at work, travelling by car or involved in formal sports could be considered to have lower values for landscape per person, but could become important in terms of landscape impacts and people if large numbers of them are affected. It is important to note that where transport infrastructure impacts on landscape, it can reduce the value of that landscape to certain population groups (e.g. recreational users), but also impact the size of those groups (i.e. reduce access for recreation) if there is physical severance or disruption of the ability to enjoy the landscape.

The population might also be scales relative to the status of the landscape, with nationally designated (e.g. National Parks, AONBs or Heritage Coast) being of value to people even if they don't visit - potentially even the entire national population. Local population can consider the impacts on households directly affected by a project (quantified as the number of households affected). Impacts on visitors to the landscape could be assessed based on visitor numbers to points in the landscape, or numbers to a length of national trail or footpath affected (before and after the transport scheme). Numbers using individual footpaths are estimated in the ORVal model (see Section 2.6.2 of the main report). The effects of severance and fragmentation of a route network and thus on visitor experience along the network is also relevant.

1.3.3 WebTAG Landscape Appraisal in Scheme Development

In relation to landscape, current WebTAG advice can be followed at all stages of development of a scheme. Topography and form, tranquillity, the presence of historic or traditional landscape elements, and land cover can be examined from the earliest stages, and reported systematically using the WebTAG Landscape Appraisal Worksheet. The level of detail, and the robustness of the conclusions of the appraisal, will increase as the design of the scheme progresses. This will be particularly the case once surveys on site can be undertaken rather than relying on information that is already likely to be available from mapping and online sources. On this basis, it is relatively straightforward currently to deliver an appraisal that is proportionate to the stage that a scheme has reached.

Designing a proportionate appraisal effort should also be considered in relation to:

- The size of transport schemes, which can be defined as spatial area, financial value or volume of transport movement;
- The number of people likely to be affected by the impacts of the scheme;
- The expected sensitivity of overall results of WebTAG to the value of landscape impacts (for example, where a lower landscape impact scheme is already favoured in WebTAG, landscape appraisal becomes less critical); and

- The potential cost/extent of mitigation for landscape impacts. Where mitigation is greater, measurement and valuation of the impacts being mitigated becomes more important.

The approaches described above show that landscape assessment and economic valuation evidence for transport schemes use more detailed approaches than the current landscape element of WebTAG. They use typologies of impacts (e.g. features of landscapes and services/ benefits for valuation). However, these typologies are not particularly compatible. Landscape is largely qualitative and also discursive, specifying stakeholder input. Economic valuation is mainly quantitative and elicits information about preferences (and hence values) without necessarily engaging stakeholders directly in the scheme development.

1.3.4 Design manual for roads and bridges

Beyond this, more detailed guidance is provided by both Highways England's "Design Manual for Roads and Bridges" (DMRB)[2] and the Landscape Institute[3]. The DMRB recommends that the main steps to be taken in carrying out landscape assessment are:

- Data collection (field and desk studies);
- Description of the baseline landscape;
- Landscape classification;
- Identifying potential impacts of the scheme; and
- Assessing significance of impacts identified.

The DMRB indicates that broadly the same information is required at each stage, but the level of detail will increase as the scheme progresses.

The Landscape Institute Guidance advises following a similarly-structured approach, comprising:

- Screening;
- Project description/specification;
- Scoping;
- Baseline;
- Identification and description of effects;
- Mitigation;
- Evaluation of effects; and
- Engaging with stakeholders.

In examining the approaches to valuing landscape, and making recommendation as to how WebTAG guidance may be updated, the study will consider the need for data requirements of any revised

2 Highways England (1993) – Design Manual for Roads and Bridges – Vol. 11, Section 3, PART 5 Landscape Effects.

3 Landscape Institute/IEMA (2017) – Guidelines for Landscape and Visual Impact Assessment – 3rd Edition, Routledge.

approach remain consistent with current best practice in terms of landscape assessment within the EIA, and current best practice transport appraisal methods (as demonstrated in the forthcoming case studies).

1.3.5 Monetary values for landscape in supplementary VfM guidance

The monetary values used in the supplementary VfM guidance are expressed as £ per hectare and are taken from benefits of different land types reviewed in ODPM (2001), as described in DCLG (2006). Those values were obtained from an extensive literature review which consolidated and considered evidence from 47 relevant studies, mainly from the UK but also from the US, Europe and Australia dating from 1984 to 2001.

There have been other studies since then, some using methods that have been developed after that review. This points to the need to update this aspect of the supplementary VfM guidance. Nevertheless, in this section we summarise that study and inflate its estimates to 2017 prices for comparison (as shown in Table A1.1).

The values are intended to represent all the ecosystem services (i.e. benefits) provided by a given type of land as much as data in the individual studies allow. This is the ‘bundle’ approach, all benefits estimated over time and expressed as £ per hectare of land as a total. The values are differentiated across seven land types, and range from £0.03m to £16.8m per ha (present value in perpetuity, 2017 prices) and are applied to direct losses of habitat, and to areas impacted adjacent to schemes.

The range of values across these categories illustrates the importance of both type of land and proximity to population in determining the importance of values and impacts. For example, extensive agricultural areas, usually in the uplands, and areas closest to people (e.g. urban parks, greenbelt) both have relatively higher values. This indicates that there are different types of services/benefits being captured in these values.

The technical scope and measurement of landscape values in the supplementary VfM guidance is the specific set of natural capital assets and services as captured in the values in Table A1.1. This is different to the use of the term landscape as a descriptive term, as assessed in non-monetary landscape appraisal techniques.

It is assumed that, alongside any revisions to monetary valuation approaches, the qualitative landscape appraisal guidance within WebTAG will continue to apply, using an approach based on landscape character assessment guidelines. In particular, issues such as landscape, capacity, sensitivity and setting, and the holistic and intrinsic values of landscape, will continue to be appraised in this manner.

Table A1.1: Values for different land types in the supplementary VfM guidance on landscape appraisal

Land Type	Value per ha per year (£)[a] (2001)	Present Value per ha (£) (2017 prices, infinite period)[b]	Comments
Urban core	75,153	16,792,186	Central urban area. Examples include public spaces and city park.
Urban Fringe (greenbelt)	1,237	276,395	Areas of transition where urban areas meet countryside.
Urban Fringe (forested land)	3,758	839,688	Forested land on urban fringes, more valuable than typical urban fringe.
Rural forested land (amenity)	9,222	2,060,564	This value represents the range of forests in the UK, including both commercial and amenity forests.
Agricultural Land (extensive)	4,384	979,561	Areas of rough grassland where extensive agricultural practices such as sheep farming dominate. May include farm buildings forming part of the agricultural holdings.
Agricultural Land (intensive)	143	31,952	This type of land is usually in farmland under intensive agriculture (usually land under food production). May include farm buildings forming a part of the agricultural holdings.
Natural and semi-natural land	9,208	2,057,436	This includes uncultivated areas, wetlands and areas with nature conservation designations.

a. Source: ODPM, 2001

b. 2001 figures are updated to 2017 prices using the Consumer Price Index. For Present Value in perpetuity calculations a percentage rate (p) of 0.03 of appreciation of WTP over time is applied to WTP values. HMT Green Book discount rates are applied (starting at 0.035), but as these decline after 30 years a default discount factor is used, based on Harvey et al (1997), of 0.001.

Values in Table A1.1 are presented in 2017 prices, which were arrived at by adjusting the 2010 values from the supplementary VfM guidance using the GDP deflator from the WebTAG Data Book for air quality[4]. The 2010 values in the supplementary VfM guidance are derived from the ODPM 2001 values (see table notes). In ODPM (2001), for the international studies, original values were converted to UK values using financial exchange rates in the year of the data, which were then deflated as above to arrive at 2001 pounds sterling.

[4] These values could also be uprated to allow for income growth. The discount rates used were drawn from a draft guidance on discounting published in the Green Book 2018 update during the project, which enabled testing of different assumptions. They vary slightly from the final recommended approach in the Green Book so should be treated as illustrative, rather than a reflection of UK Government appraisal guidance. For example, our test does not include income uprating

DCLG (2006[5]) draws on the values reviewed and collated in ODPM (2001), which covered 47 studies. The majority of the values from the review present welfare value estimates for environmental benefits provided by different types of undeveloped land. The studies from which valuation evidence was taken were selected according to the following criteria:

- **Study subject**: the review was limited to those studies estimating the monetary value of relevant external benefits, namely:
    - Recreation: refers to activities such as sport (both formal and informal), leisure and tourism;
    - Landscape: refers to the fabric of the land into which development is placed, along with a constantly evolving entity fashioned by that development;
    - Ecology: refers to the habitats of plants and animals which comprise the natural world, and the particular assemblages of plants and animals which are a part of those habitats;
    - Cultural Heritage: refers to the rich legacy of buildings and other artefacts, which underpin long periods of settlement of a land;
    - Hydrology: refers to the provision of natural hydrological regimes;
    - Air Quality and Climate: refers to the modification of the micro-climate through variance in albedo;
    - Tranquillity: refers to the role of undeveloped land in reducing exposure to noise, vibration, and excessive light for local residents;
    - Accessibility: refers to the provision of green corridors that weave their way through the urban fabric, providing pedestrian and cycle routes; and
    - Soil: refers to the provision of nutritional and mineral soil resources.

  There were, in fact, no studies available for tranquillity and accessibility, and several services only had values for a subset of the land types. Second, only those studies valuing benefits associated with the types of undeveloped land were selected.

- **Study context:** empirical evidence (and indeed psychological literature and alternative economic theories) show (and predict) that context can influence the amount of WTP (and WTA – willingness to accept compensation) significantly so that people tend to be willing to pay more to maintain quality and avoid deterioration than they are to improve quality. Thus, using studies that estimate preferences to improve environmental resources would possibly lead to the underestimation of the losses if development (and negative impact on landscape) is allowed. Therefore, the review focused in those studies that measure people's WTP to maintain the current status of an external benefit or to avoid a deterioration in that status.

- **Study origin:** Following the first choice of studies originating in the UK, the second choice for selection is for studies from countries that have similar socio-economic characteristics, where there are no studies in a particular cell of the land type, this criterion was relaxed.

- **Study methodology:** Only studies that use robust methodologies that are based on the theory of welfare economics were selected. These included studies that use both revealed and stated preference techniques. The database contained more studies using stated than revealed preference techniques. One reason for this was that there seemed to be more

[5] DCLG (2006) Valuing the external benefits of undeveloped land: main document. London. http://webarchive.nationalarchives.gov.uk/20120920043019/http://www.communities.gov.uk/documents/planningandbuilding/pdf/158136.pdf

stated preference studies in the literature at the time. But another, possibly more important, reason was that revealed preference (especially hedonic pricing) was found to be too specific to the characteristics of the actual market they are associated with to be appropriate indicators of external benefits elsewhere. They are also specific to the impacts that have already been experienced, while stated preference can be used to value impacts yet to happen.

- **Quality of statistical results:** Studies that report their results in a way that allows the **assessment** of their validity and reliability were selected, so that studies which reported very poor statistical results were excluded**.**

- **Study age:** Design and application of economic valuation technical evolve constantly. Therefore, only those studies undertaken in or after 1990 (with bias towards the second half of that decade) were reviewed in the first instance. However, several studies that took place before this cut-off date, but that filled a gap in the literature (or were deemed of acceptable quality), were also included in the database.

1.3.6 Comparing WebTAG to Natural Capital Assets and Ecosystem Services

In order to update the current monetary values in the supplementary VfM guidance for landscape impacts, we need to decide on which value evidence is appropriate and how to use them, while taking into account the changes in the way landscape benefits are defined and measured since the last iteration of these values; as well as updates in the literature.

As DfT (2016) recognises, "*…it is the ecosystem services provided by natural capital that affect public value, HMT and the Department for the Environment, Food and Rural Affairs (Defra) recommend the use of approaches based on an understanding of ecosystem services to measure impacts on natural capital in appraisal and value for money assessments.*"

An Asset - Service matrix as shown in Figure A1.3 can be used to compare the natural capital framework with the way land, landscape and benefits are covered by the supplementary VfM guidance. Definitions of the assets and services involved are provided in Appendix 1 as used by the Natural Capital Committee in its work, such as its natural capital risk assessment (see NCC 2015 for details).

The rows in Figure A1.3 are the natural capital asset categories recommended by the Natural Capital Committee with the addition of 'atmosphere' as an asset. These rows are noticeably different to the land types used to define monetary values in the supplementary VfM guidance (shown in Table A1.1). They have similarities in that the land types reflect several of the asset categories, but are different due to the land types also reflecting geographic context (e.g. to urban areas) which is a key determinant of several monetary values.

The columns in Figure A1.3 are the benefits recommended by the Committee for valuation based on ecosystem services[6]. To capture all natural capital, abiotic benefits could be added to the list of benefits. Impacts on minerals are likely to be the main abiotic impact that is relevant to UK transport

[6] An alternative typology is the Millennium Ecosystem assessment (MEA): provisioning, regulating and cultural. However, as the priorities for WebTAG cover some but not all of both regulating and cultural services, there is no significant advantage to using it. Both typologies can be expanded to accommodate greater detail where required.

schemes. However, mineral resources are market goods, which should therefore be reflected in the price of land and their exploitation should be captured in the appraisal of a transport scheme if the scheme impacts on the value of mineral resources. This also applies to energy, food and fibre, so all these columns are shaded blue.

The Natural Capital Committee's natural capital assets typology captures Landscape Aesthetics, Biodiversity and Water Environment. However, from a landscape professional's viewpoint, this is not considered to take full account of the cultural and perceptual aspects of landscape.

The shading in Figure A1.3 illustrates three relationships between landscape in the supplementary VfM guidance and wider ecosystem services and natural capital assets:

- Hashed cells are not considered to be significant for appraisal, either because the benefit is not produced (e.g. minerals from the atmosphere) or are of very low value (e.g. food produced from woodland). Therefore, they are excluded from project scope.
- Blue shaded cells are impacts that are covered in parts of WebTAG other than landscape. For example, ecology may be covered under the 'Biodiversity' environmental capital in WebTAG. Therefore, blue cells are potential overlaps where there is a risk of double-counting.
- Cells with a dot are where a method already exists in WebTAG to assess impacts from transport, but its practical application to landscape needs to be evaluated. For example, WebTAG has methods to assess the impacts of vehicle noise, but within the landscape category, it is the impact of trees in reducing noise impacts of transport that needs to be assessed.

Figure A1.3 shows extensive overlaps between landscape and other parts of WebTAG across different ecosystem services and natural capital assets:

- Several services are market goods (energy, food, fibre and minerals) and therefore are assumed to be captured under the monetary values of market impacts (especially through land values) in WebTAG.
- Other services are covered in both landscape and other WebTAG appraisal categories: urban (townscape in WebTAG outside landscape), clean water and flood hazard protection (hydrology), and wildlife (ecology).

Landscape Coverage in WebTAG

	Aesthetics	Clean Air	Clean Water	Energy	Climate Regulation	Fibre	Food	Hazard Protection (flooding)	Recreation	Noise	Wildlife	Minerals
Woodland	-	●	-	-	●	-	-	-	-	●	-	-
Grassland	-	●	-	-	●	-	-	-	-	●	-	-
Mountain, moors & heath	-	●	-	-	●	-	-	-	-	●	-	-
Enclosed farmland	-	●	-	-	●	-	-	-	-	●	-	-
Freshwater	-	●	-	-	●	-	-	-	-	●	-	-
Urban	-	●	-	-	●	-	-	-	-	●	-	-
Coastal margins	-	●	-	-	●	-	-	-	-	●	-	-
Marine	-	●	-	-	●	-	-	-	-	●	-	-
Atmosphere	-	●	-	-	●	-	-	-	-	●	-	-

●	Methods in other parts of WebTAG
	Suggested exclusions from scope
	Overlap between Landscape and other parts of WebTAG

Figure A1.3: Asset-Service Matrix Showing Coverage of Landscape in WebTAG

The cells in white are the priorities for any update to the landscape category in the supplementary VfM guidance. They cover five services: aesthetics, clean air, climate regulation, recreation and noise regulation. For three of these services there are already methods in use in WebTAG to assess impacts from transport, so these will be a starting point to assess the effects of impacts on landscape.

Over half of the cells in Figure A1.3 are shaded blue, suggesting that these ecosystem services are currently captured in parts of WebTAG other than Landscape. Where there are overlaps, it will be necessary to avoid double-counting by either:

a) Excluding them from the Landscape category and hence this study (i.e. potentially overlapping impacts/ blue shaded cells), or

b) Including them within the Landscape category of WebTAG and recommend changes to other parts of the WebTAG structure.

A complicating factor in this approach is that the current monetary values in the supplementary VfM guidance (as described in Table A1.1) are bundled – they represent different groups of benefits or services. If the most suitable values for landscape are part of a bundle that overlaps with other areas of WebTAG, then using them will lead to double counting necessitating changes to other areas of WebTAG.

1.4 Potential Landscape Valuation through Value Transfer

The process of transferring existing valuations from a context in which primary research was undertaken (the study site) to a new ecological and socio-economic context (the assessment site) is called "value transfer" or "benefit transfer". This is an imperfect but frequently a valid alternative to primary valuation (Liu et al. 2012) – in particular when projects are in outline stage and when there are many hundreds and even thousands of small and similar assessments to make.

1.4.1 UK Value Transfer Guidance (2010)

In the UK, Defra published official guidance on how to select and adjust the existing evidence (eftec, 2010). The key questions that are relevant for designing primary research for economic valuation are also relevant for value transfer and apply to the valuation of the landscape impacts of transport schemes:

1. What is the good?

In this case the answer is landscape. But how do we define it? It has many attributes and types that are affected differently by different transport schemes. The challenge is to find a way that can reflect this variety in a pragmatic way.

2. What's the change?

Economic valuation is about estimating the preferences of individuals for a change in the quality or quantity of a good. It's not about the absolute value of it that will hold true in every context. Therefore, the change needs to be defined and measured (in bio-physical and other quantitative terms) first, before economic valuation can be added. In this case, it's not just about the hectare of land / area of landscape affected but also the resulting changes to various ecosystem services, which can be assessed individually or as a bundle.

Individual ecosystem services can be valued separately and the values can be added up. This is useful if services can be identified individually and impacted differently by a scheme (e.g. water regulation service is not impacted but recreational opportunities are curtailed). As ecosystems produce a complex and inter-related set of services, separate analysis of each service needs to be undertaken carefully to avoid double-counting or indeed underestimating the synergies between services.

Identifying and quantifying all the services provided by an ecosystem and valuing them as a whole would be a 'bundled' approach. This is useful when, say, a transport scheme is likely to affect all ecosystem services. This whole 'bundle' approach to valuing ecosystems would miss the nuances of different services provided at different levels but should suffice at generating ball park figures for initial planning stages.

3. Whose values?

As economic valuation is about individuals' preferences, all affected individuals should count. These include those who are directly (and positively or negatively) affected by the change assessed; and indirectly (e.g. through paying for the cost of a transport scheme even if not affected by the scheme in one way or another). In this case, affected groups include residents, visitors, passers-by (e.g. those who drive by) and non-users.

4. Which monetary value evidence?

The key is that the evidence used needs to be appropriate and robust. Criteria reported from the ODPM (2001) study in Section 1.2.4 are good examples of how this question can be addressed.

Several 'valuation tools' have been developed to combine qualitative and quantitative analysis to reduce the effort needed for value transfer in appraisal. Examples include the Benefits Assessment Guide of the Environment Agency for appraising investments in water quality in the context of implementing the Water Framework Directive; and Economic Value Look-Up Tool developed by eftec for Defra to make finding the relevant value evidence easier[7]. A review of such tools to value the benefits of green infrastructure was conducted by eftec for Natural England[8].

Some of the tools require a lot of the information about a specific landscape to be collected and inputted by the user. Others contain a lot of the information from the literature already requiring the user to make the necessary adjustments to adapt the estimates to their context.

1.4.2 Method development since 2010

Liu et al. (2012) describe how values may be transferred both spatially, across different sites, and over time, but points out that this must be done with care, as most natural capital values are

[7] https://www.eftec.co.uk/project/%20%09environmental-value-look-evl-tool

[8] http://publications.naturalengland.org.uk/publication/6264318517575680

context specific.

Significant expertise and applied experience is required to conduct value transfer with confidence, and to understand when it is and is not appropriate (Natural Capital Coalition, 2016). For example, Czajkowski et al. (2015) examined international value transfer in the Baltic Sea and showed different preferences across countries and different individual values connected to respondents' preferences and cultural backgrounds, and differences in the availability of substitute sites (e.g., lakes and rivers, the North Sea for Germany and Denmark).

Johnston et al's (2015) review of value transfer approaches cited Bennett's (2006) set of criteria, including five key requirements for process validity, for assessing value transfer:

- Biophysical conditions in the source case must be similar to those in the target case;
- Scale of environmental change considered in the source must approximate the target;
- Socioeconomic characteristics of the population impacted by the change investigated in the source must approach those of the target population;
- Frame or setting in which the valuation was made at the source must be close to that of the target;
- Source study has to have been conducted in a technically satisfactory fashion.

For transfer of a WTP estimate to a different site and a different population, several approaches are distinguished:

Unit value transfer

(1) **a single unadjusted value –** *the value is taken from the original study and used in the appraisal without any adjustments*. Any significant "scaling up" or "scaling down" of benefits to account for quantity differences between the study and policy site requires strong assumptions, including that per unit WTP is invariant to the total quantity of the good consumed

(2) **an adjusted value -** *the value from the original study is adjusted to reflect the differences between the study and the appraisal in terms of the good, the change, the population affected and other contextual factors, based on availability of data and expert opinion.* For example, one might use an appropriate price index to account for differences in real currency value between the time period during which the primary study was conducted and the period for which benefit estimates are required. These types of scaling adjustments often involve strong assumptions, the consequences of which analysts should be aware of. For example, the simple (e.g., linear) scaling of WTP estimates according to aggregate measures of income or purchasing power parity implies strong assumptions about the structure of preferences. As a result, this type of ex post scaling or adjustment will not always increase transfer accuracy. In some cases, it may be the source of additional transfer error.

A variant of adjusted unit value transfer is the use of administratively approved values (Rosenberger and Loomis 2003). In this case, transferred estimates are not provided through a formal, quantitative adjustment of a prior benefit estimate, but are rather values derived using a subjective and sometimes arbitrary process within a government agency, typically based on some combination of “empirical evidence from the literature, expert judgment, and political screening” (Rosenberger and Loomis 2003, p. 456).

(3) a measure of central tendency such as a mean or median value from a set of prior studies, **or (4) a range of estimates from a set of prior studies.** These are straightforward extensions of the approaches described above. The primary difference is that the analyst uses information from multiple prior studies rather than a single study. From these estimates one can either conduct an adjusted or unadjusted unit value transfer using a measure of central tendency or create a meta function (see below).

Function transfer

Function transfers use a benefit function derived from a primary study or set of prior studies to calculate a welfare estimate calibrated to selected characteristics of a policy site (Loomis 1992; Rosenberger and Loomis 2003). There are two primary requirements for a benefit function transfer. The first requirement is that the chosen studies report a function that explains the variation in value estimates using a number of explanatory variables (or factors). Second, such a function can be run for the appraisal site using the data from the site on these factors.

It may be possible to develop valuation evidence that links values from a primary research into landscape, with scoring of landscape features such as in Swetnam’s (2017) modelling of a visual quality index (VQI) for different users (pedestrians, cyclists, car users) viewshed (ZVI). This approach is not expected to capture the holistic value of landscape. However, it can potentially capture a greater proportion of landscape value and/or do so more robustly (due to transfer validity being tested against the numerical indexes used) than current approaches.

Meta-Analysis

Meta-analysis may be defined as the quantitative synthesis of evidence on a particular empirical outcome, with evidence gathered from prior primary studies. Meta-analysis in environmental economics is most often accomplished using statistical analysis, called meta-regression models (MRMs). Within these models, the dependent variable in a classical or Bayesian MRM is a comparable empirical outcome drawn from existing primary studies, with independent moderator variables representing observable factors that are hypothesized to explain variation in the outcome across observations.

Methodological factors shown to influence WTP in past MRMs include study type, survey implementation method, response rate, question format, treatment of outliers/ protests, econometric methods, and other factors.

1.4.3 Unit values in Value Transfer

In applying value transfer to transport schemes it is necessary to match the evidence on valuation of environmental impacts to the expected impacts of the transport investment. For the impact currently captured under landscape in the supplementary VfM guidance, this means using per ha unit values, multiplied by expected hectares of land affected.

However, not all economic valuation evidence is generated in per hectare values. It may be derived per person (e.g. visitor, resident) or per household. A further complication is the need to link data to those holding different types of values (i.e. users/ non-users).

The data in DCLG (2006) was generated from a range of studies with different units (hectare, visitor or household). Its per visitor and per household values were thus converted into per ha values to enable their use in the supplementary VfM guidance. Current GIS capabilities can facilitate and improve this conversion of data. Suitable approaches are specific to different ecosystem services, and are described in the discussion of each service within this report.

For example, per visitor values are derived and calculated for sites within the ORVal online tool (see Section 2.6.2). Per household values can be applied in transport appraisals by using GIS to identify the number of households impacted by a scheme. This is a straightforward GIS procedure, requiring mapping of an appropriate buffer to the transport scheme, and identifying the households within it from readily available data. Using such GIS approaches could help avoid the sometimes simplistic application of £ per hectare values, especially where per user values are the most significant ones to analyse.

1.5 Potential for Primary Landscape Valuation

1.5.1 eftec et al Scoping Studies

Two studies, (eftec, 2007 and 2009) were undertaken specifically to address the question of whether and how impacts on landscape from transport infrastructure could be valued and included in WebTAG. The studies particularly focused on the effects on the visual appearance of the landscape and impacts of traffic flow instead of valuing the service loss from land taken for transport infrastructure. The studies did not reach the stage of a full economic valuation study, the results of which could have been integrated into WebTAG. Nevertheless, the typologies they use to classify impacts are informative for further work.

eftec et al (2007) considered 20 transport scheme types, as shown in Table A1.2. These were identified from an initial list of approximately 70 and reflect distinctions between:

- Area-based and linear schemes - often the landscape consequences of area-based schemes will be a function not just of built infrastructure, but also their supporting requirements for access (either road or rail). With regards to linear schemes, rail schemes, particularly high speed lines, have restricted scope to avoid landscape impacts due to constraints on vertical and horizontal alignments, although the actual scheme footprint may be smaller, and the effect on tranquillity more transient, than in the case of roads. Increasingly highways are aligned along or close to existing routes and as a result the landscape impact is a function of the effect within an existing corridor.
- Presence of transport/other infrastructure - typically the trend then was for new transport schemes to focus on existing infrastructure or to take place within existing transport corridors, rather than creating new corridors. Hence the implication is that impacts to landscape character and visual amenity are more likely to be ‘incremental’ to existing effects, rather than a starker impact concerning a new scheme in an otherwise pristine environment.

The Impacts of transport schemes considered by eftec et al (2007) included:

- Primary and secondary infrastructure impacts as related to the landscape (character and visual amenity);

- Movement-based impacts associated with heavy goods vehicles (HGVs) in particular;
- Lighting impacts from both infrastructure and vehicles;
- Tranquillity and/or related amenity effects (e.g. recreation), and
- Maintenance effects (for example, the removal of trees adjacent to rail lines to avoid leaves on the line).

Table A1.2: Initial recommendation of schemes in eftec et al (2007)

Category	**Scheme**
Highway – Offline	Single carriageway
	Dual carriageway (offline or bypass)
	Dual 3 motorway
Highway - Online Widening	Single to dual carriageway
	Dual 3 to dual 4 motorway
Highway – Junction	Dual carriageway grade separated
	Motorway – motorway grade separated
	Motorway – motorway merge
Highway – Other	Motorway bridge
	Twin bore tunnel portal
	Automatic traffic management
Non-Highway	Electrification
	High speed line
	New line
	Additional tracks
	Park & Ride
	Surface access capacity at airports
Ancillary Elements	Directional signs
	High mast lighting
	Rock face cuttings

eftec et al (2009) tested the feasibility of using stated preference methods scoped in their 2007 study to value the landscape (meaning visual amenity) impacts of transport schemes. The scope of transport scheme types and the impacts considered were based on a series of example schemes, shown in Table A1.3. This led to design of a pilot survey, which concluded that there was a marked difference between the perceived impacts of on-line and off-line new capacity as the latter requires new land take and change in the look of the landscape.

Table A1.3: Summary of scheme scenarios for pilot questionnaire

Scenario & scheme type	Landscape type	Location	Details
1. Dual carriageway (offline)	Rolling lowlands	Kenilworth, Warwickshire (within 1 mile west of Kenilworth)	Proposed route close to Kenilworth Castle Approximately 7.5 miles in length
2a. Single carriageway (offline)*	Moors hills and dales	Peak District	Proposed route within National Park Unique landscape Approximately 20 miles in length
2b. Single carriageway (offline)*	Rolling lowlands	Westbury, Dorset	Proposed route close to Unique landscape feature White Hill figure and Iron Age fort Approximately 10 miles in length
3. High speed rail (offline)	Rolling lowlands	Hemel Hempstead, Hertfordshire (1 mile south-west and west of Hemel Hempstead)	Proposed route close to Chilterns AoNB Section of London – Birmingham line
4. Widening single to dual carriageway (online)	Lowlands	Grantham, Lincolnshire (within 3 miles west of Grantham)	Scattered houses and farmland Approximately 7 miles in length
5. Widening dual 3 to dual 4 (online)	Rolling lowlands	Kenilworth, Warwickshire (within 5 miles south-west of Kenilworth)	Farmland Approximately 20 miles in length
6. Active traffic management (online)	Rolling lowlands	Kenilworth, Warwickshire (within 5 miles south-west of Kenilworth)	Farmland Approximately 20 miles in length
7. Park and ride	Rolling lowlands	Blandford Forum, Dorset (within 1 mile north-west of Blandford Forum	Designated AoNB

The study defined the relevant population, i.e. those affected by the landscape impacts from transport schemes, as:

A. Homeowners who are directly affected by landscape change in that it impacts upon house prices.

B. Those experiencing welfare changes due to landscape change near to their home, which is (i) not captured in population A above, i.e. no effect on house price, and (ii) is to some extent unavoidable (e.g. perhaps through impact on recreation opportunities linked to the natural landscape).

C. Travellers/visitors who can choose to avoid the impacts concerned.

D. Non-users who nonetheless hold values for the impacts concerned.

In the 2009 pilot survey three distance bands (distance from the transport infrastructure project) were considered

- 'Very close': potential direct visual impact on property;
- 'Close': potential indirect visual impact on property; and
- 'Further away': within 1-5 miles of proposed location for scheme.

This study suggested that stated preference techniques could be successfully applied to value the landscape impacts of transport schemes. The pilot study was able to generate reasonable monetary values. These had very low certainty due to the small sample sizes used in a pilot.

1.5.2 Atkins et al (2013) Review of WebTAG and Ecosystem Services

Atkins et al (2013) identified a number of ecosystem services for which the core valuation literature provides the potential for early inclusion into WebTAG. Recommended ecosystem services included:

- **Carbon sequestration**: carbon emissions from transport vehicles are already monetised in WebTAG, and there is research currently being carried out into valuing embodied carbon. Including changes in carbon emission from changes in land use and habitat would enable another important source of carbon emissions to be monetised through WebTAG. The UK National Ecosystem Assessment (UKNEA, 2011) provides some headline data on habitat carbon sequestration rates. A review could be undertaken to establish typical rates for habitat change and degradation of most relevance to transport schemes, including beneficial impacts associated with landscaping. Testing should be undertaken to ensure inclusion of such carbon values are proportionate.

- **Urban green spaces, green belts and recreational areas**: amenity values of undeveloped land are already included in WebTAG, but only in relation to housing development. There is the potential to expand such valuation to the more direct effects of transport schemes. The UKNEA assessment (Mourato et al, 2010; Perino et al., 2010) provides the basis for updating the DCLG (2006) study with a more detailed spatially disaggregated valuation system, which would provide a basis for bringing local parameters into the valuation process (which would be in keeping with the existing detailed qualitative assessments). Atkins et al (2013) suggested a study could be undertaken to build on this work to establish an improved system for WebTAG. Amenity values are relevant to a number of WebTAG units, as such a standalone, additional valuation unit could be considered.

Atkins et al (2013) identified the following services as potentials for early inclusion in WebTAG through the existing literature:

- Wetlands;
- Changes in water quality;

- Coastal habitats.

They also concluded that the following could merit further/continued research:

- Building on the research undertaken by eftec (2009) that linked transport interventions to landscape; and
- Further analytical work and identification of appropriate databases from the available literature to develop measures of impacts of transport on water quantity, national or regional recreational sites, flooding and introduction of invasive species.

The above final conclusions from Atkins et al (2013) are more conservative than the intermediate sections of the same report. For example, Table A1.4 provides an overview of the specific ecosystem services they state as possible to include in WebTAG. Note that ecosystem services considered in Atkins et al (2013) do not perfectly align with those listed in NCC (2017).

Additions have been made to Table A1.4 **in bold** to illustrate the actual coverage of the values in the Landscape category in WebTAG (i.e. reflecting the services valued in the 2001 ODPM study).

With respect to Table A1.4, Aktins et al (2013) suggest that:

- Some of the impacts of transport schemes that are evaluated qualitatively could perhaps be valued in monetary terms, given the literature on valuation. Examples would be the effects of losses in habitat and biodiversity on recreation; changes in water flows and their impacts on recreation and aesthetic values; and the effects of changes in soil quality on GHGs.
- Where a P has been entered it is felt that WebTAG does not currently address a potential ecosystem service impact. In general, being able to provide guidance on how to assess these impacts may require further research before they could be adequately understood to include and value in WebTAG.

Table A1.4. WebTAG categories and ESS

Ecosystem Service of vegetation	**Web TAG Unit**	**Scheme appraisal**	**AQ**	**GHG**	**Noise**	**Landsc**	**Townsc**	**Heritage**	**Biodiv**	**Water**	**Journey amb.**
Food		M[9]	M	P					Q	Q	
Fuel and fibre		M	P						Q	Q	
Water supply										Q	
Wild species diversity					Q				Q	Q	
Recreation			P		P	P **M**	P	P	Q	P	
Aesthetic value						Q. **M**	Q	P	P	P	Q
Cultural heritage			Q					Q			
Climate regulation				M		**M**			P		
Hazard regulation									P	Q	
Disease and pest regulation									Q		
Noise regulation					M	**M**					
Water quality regulation			P						Q	Q	
Soil quality regulation		(M[10])		P					Q		
Air quality regulation			M			**M**					

Key: Q: Impact currently included (at least partially) through a qualitative assessment. **M:** impact currently included in monetary terms. P: Potential impact that could be added to WebTAG. Blank: No/limited link between ESS and WebTAG unit.

[9] In land value
[10] Supporting service

1.6 Conclusions on Valuing Landscape in WebTAG

Table A1.5 shows the current coverage of the benefits from natural capital (examined in Figure A1.3 and Table A1.4) in appraisals using WebTAG and the supplementary VfM guidance.

Table A1.5: Coverage of Benefits from Natural Capital in Current Appraisal Process

Benefits	In current appraisal process?		Priority for 'Landscape' Guidance Update?
	In the supplementary landscape values	Other parts of WebTAG	
Aesthetics	Yes		Yes
Clean Air[1] **(Regulation of Air quality)**	No		Yes
Clean Water	Yes	Yes, under water environment	No, overlap and very local-context dependent benefit
Energy	No	Yes, under market impacts	No
Climate Regulation	No		Yes
Fibre	No	Yes, under market impacts	No
Food			
Hazard Protection (Flooding)	Yes	Yes, under water environment	No, overlap and very local-context dependent benefit
Recreation	Yes		Yes
Noise Regulation[1]	No		Yes
Wildlife	Yes, under ecology	Yes, under biodiversity	No, overlap and very challenging to value
Minerals	No	Yes, under market impacts	No

(1) i.e. change in exposure due to the regulating effects of vegetation.

The prioritisation in Table A1.5 is straightforward in most cases, but two services are ruled out for overlap and methodological reasons:

- Clean water and hazard protection (flooding) are a gap in WebTAG but are known to require locally specific modelling to appraise to an acceptable standard (ADAS & eftec, 2014).
- In the case of wildlife, the EVL tool (see Section 2 below) only states that some biodiversity values are captured in valuations for other final goods and services (e.g. timber, carbon sequestration and recreation including wildlife watching). It excludes further elements of the value of biodiversity such as the benefits associated with the conservation of habitats and wildlife, but provides a list of UK studies capturing these aspects of biodiversity. However, this has strong overlap with the 'biodiversity' impact category in WebTAG.

This suggests that updating the landscape values in the guidance should focus on:

- Landscape aesthetics/visual amenity
- Air quality
- Noise/Tranquillity
- Recreation
- Carbon

The next section presents the new literature (not reflected in EVL Tool or the supplementary VfM guidance) reviewed under these categories.

2.0 Review of Economic Valuation Literature

This Section examines the availability of economic valuation evidence that could be applied in an update to the Landscape category of WebTAG. The literature reviewed covers:

- The Environmental Values Lookup Tool, which is referenced in WebTAG as a basis for valuation evidence in Government project appraisal.
- Studies for five areas prioritised based on consideration of WebTAG coverage in Figure A1.3: Landscape aesthetics/visual amenity, Air quality, Noise/Tranquillity, Climate regulation and Recreation.
- Other relevant evidence (on urban environments, habituation effects, and house prices)

2.1 Environmental Values Lookup Tool

The EVL Tool (eftec, 2015) was developed for Defra to present a broad review of the economic valuation literature on a select set of broad habitats and ecosystem services in order to facilitate quick access to this literature for policy appraisal by Government departments (see Box 2.1). It involved comprehensive searches for evidence in the economic valuation literature to complete an Asset – Service matrix like the one in Figure A1.3. The Tool provides economic valuation evidence on ecosystem services for eight broad habitats', i.e.:

- Coastal margins
- Enclosed farmland
- Freshwater, wetlands and floodplains
- Marine
- Mountains, moors and heaths
- Semi-natural grasslands
- Urban (green space)
- Woodland

Box 2.1: The Environmental Value Look-up Tool (EVL)

The EVL tool is an Excel-based appraisal tool providing a set of 'look-up' values in order to help analysts take better (monetary) account of environmental impacts in government appraisals. The look-up values are intended to be used at the early stage of an appraisal and help to establish an indication of the possible scale of costs and benefits. This 'first cut' assessment complements - rather than replaces – the option for more detailed analysis of environmental costs and benefits.

While the tool is primarily designed for government analysts, it is also relevant to private sector and non-government organisations with an interest in using valuation evidence for investment appraisals and corporate natural capital accounting exercises.

The EVL tool comprises three main components (i.e., database, user interface and aggregation work sheet) and is accompanied by a user guide. The database provides the set of look-up values that have been drawn from the available literature. These values are referred to as 'indicative' values, which emphasises that they represent broad generalisations of the value of different environmental goods and impacts. The user interface allows users to select indicative values according to: (i) the type of environmental impact/good; and (ii) the broad habitat they choose. When interested in aggregate environmental benefit and cost estimates, the user can use the aggregation worksheet to calculate aggregate values based on the selected indicative value. The worksheet allows for the calculation of equivalent annual values as well as present value costs and benefits (discounted in line with the HM Treasury (2003) Green Book guidance).

The indicative values were produced by screening over 350 UK-relevant studies (excluding existing government guidance) published between 2000 and 2015. The studies deemed suitable for being interpreted in a broad and generalised way were then consolidated to produce a single range of indicative values for each combination of broad habitat and environmental impact/good.

Overall, the tool covers the 16 environmental impact/good categories listed below. It is however important to note in this respect that this list of environmental impacts/goods is not covered in its entirety for each single habitat type:

- Aesthetic value
- Air quality regulation
- Biodiversity – cultural values including habitats and wildlife conservation
- Climate regulation
- Cultural heritage; recreation and tourism; aesthetic value
- Fibre and fuel
- Food
- Food: Crops
- Food: Livestock
- Local environmental quality
- Natural hazard regulation
- Noise pollution
- Recreation and tourism
- Recreation and tourism; aesthetic value; biodiversity
- Recreation and tourism; human health
- Water purification and waste treatment; recreation and tourism, aesthetic value, biodiversity

Based on eftec (2015)

The Asset-Service matrix used here and in the EVL tool enables a quick identification of literature to be considered and priorities for future research.

Figure A2.1 shows the areas for which the EVL tool provides indicative values (i.e. green cells) and those for which it does not provide indicative values but refers to sources containing valuations (i.e. orange cells). For 'clean air', 'climate regulation', 'noise' and 'wildlife' EVL refers to the existing government guidance, which is reproduced in Table A2.1. This guidance could be applied to value these impacts of transport schemes in WebTAG. It should be noted that the impact considered here is that resulting from a change in the natural environment – i.e. the ability of vegetation to mitigate noise or air pollution – and not the noise or air pollution impact of transport vehicles/ infrastructure.

Applying this guidance would improve the accuracy with which services are valued, but this will be more complex (and costly/ time-consuming) than applying indicative values. Therefore, it may be cost-effective to apply the guidance in a smaller number of appraisals (i.e. transport schemes with more significant impacts in these areas).

Table A2.1: Benefits and government guidance referenced by the EVL tool

Benefit	Government guidance referred to by EVL
Clean air	Department for Environment, Food and Rural Affairs (2011) Air Quality Damage Cost Guidance.
	This guidance document provides valuations for air quality damage costs. It also describes the methodologies available to value air quality impacts from proposals (e.g. projects or policies) that lead to changes in emissions of air pollutant, either as a direct objective of the proposal or as a secondary impact.
Climate regulation	Department for Energy and Climate Change (DECC) (2014). Valuation of energy use and greenhouse gas emissions, supplementary guidance to the HM Treasury Green Book on Appraisal and Evaluation in Central Government.
	This guidance document provides valuation for greenhouse gas emissions. It also describes the methodology to help assess proposals that have a direct impact on energy use and supply and those with an indirect impact through planning, land use change, construction or the introduction of new products that use energy.
Noise	Department for Environment, Food and Rural Affairs (2014) Environmental Noise: Valuing impacts on: sleep disturbance, annoyance, hypertension, productivity and quiet.
	This guidance document provides valuation for changes in noise. It also describes the methodology to value the effects of changes in noise exposure on sleep disturbance, annoyance, hypertension and related diseases. Estimates are provided for road, rail and aircraft exposure.

2.1.1 Comparisons of Coverage

Comparison of Figures A1.3 and A2.1 suggest what additional values would need to be provided to make the EVL Tool coverage match the kind of assets and services affected by transport schemes, and of course the type of impact which is not explicitly shown in the monetary valuation figures.

The EVL tool covers the natural capital assets listed in the asset-service matrix (Figure A2.1) except atmosphere. Although not covered as an asset, impacts on atmosphere are covered through consideration of air quality. ‘Hazard protection’ is also covered through links to guidance on valuing reductions in flood risk and coastal erosion provided by the Environment Agency - hence the cells in Figure A1.3 are white. This guidance provides a description of the approach to valuing the benefits of flood and coastal erosion risk management (FCERM) as a result of flood and coastal erosion projects or strategies, but must be applied on a case by case basis, reflecting the highly context-dependent nature of flood risk reduction benefits.

	Aesthetics	Clean Air	Clean Water	Energy	Climate Regulation	Fibre	Food	Hazard Protection (flooding)	Recreation	Noise	Wildlife	Minerals
Woodland							Excl.					
Grassland				Excl.								
Mountain, moors & heath				Excl.								
Enclosed farmland												
Freshwater						Excl.						
Urban												
Coastal margins												
Marine						Excl.						
Atmosphere			Excl.			Excl.	Excl.	Excl.				Excl.

EVL tool provides indicative values

EVL tool provides no indicative values, but refers to sources containing valuations

Excl. Suggested exclusion from scope of this project (see Figure A1.3)

Figure A2.1: Coverage of assets/services in the EVL Tool

2.2 Valuing the Services Covered by the Current Landscape Values

This section examines published evidence for five services prioritised based on consideration of WebTAG coverage in Figure A1.3: Landscape aesthetics/visual amenity, Air quality, Noise/ Tranquillity, Climate regulation and Recreation.

The literature search for these services was scoped to update the Environmental Values Look-up (EVL) Tool developed for Defra in 2014. The EVL Tool was designed to provide a quick access and clear audit trailed summary of value evidence to inform appraisal by Government. It involved comprehensive searches for evidence across a range of ecosystem services which is discussed further in Section 4.

Therefore, the literature search for this study focused on new evidence published in academic journals between 2014 and 2017. Searches have been conducted using keywords (e.g. air quality valuation, aesthetic value, landscape, landscape valuation, transport schemes environmental impacts) on Google Scholar and in the EVRI database[11]. Studies based on UK data have been favoured, but studies from elsewhere have not been entirely excluded. Non-UK studies can demonstrate feasibility of methods and they can bring new evidence of potential application of valuation methods in the UK in future.

The specific aims of the review are to:

- Identify monetary values of environmental impacts that could be used in the Landscape category in the guidance;
- Identify the units used to define and measure environmental impacts (e.g. 1dB increased exposure to a household per year). For appraisal to be practical, economic valuation evidence needs to be expressed in units which can match evidence generated in transport scheme development and impact assessment. A match between these units is required in order for valuation evidence to be applied, and
- Reflect the valuation best-practice to benchmark relevant UK evidence against the international literature, and understand what methods can potentially be applied in the UK (should primary research be deemed appropriate following this study). Value transfer selection criteria in accord with UK guidelines (eftec, 2010)[12], and subsequent development of value transfer methods (see Annex Section 2.2) were used to ensure that potential values are robust and relevant.

The review has identified studies that could provide monetary values, and/or evidence to help apply them, within the appraisal of Landscape in WebTAG. It has noted the values and the way they are constructed (e.g. the methods used in studies, and the units used). The robustness of this evidence is assessed based on: i) suitable review having been undertaken of those studies (e.g. indicated by publication in peer-reviewed journals or following review for public policy purposes), and ii) suitability of the evidence for value transfer (as reflected in value transfer criteria).

[11] http://www.evri.ca/

[12] https://www.gov.uk/government/publications/valuing-environmental-impacts-guidelines-for-the-use-of-value-transfer

2.3 Landscape Aesthetics

Current WebTAG methodology for evaluating landscape impacts uses a seven-point scale based on the scheme's fit with the landscape or landform, visual amenity, loss of character, degree of mitigation and effect on policies. This qualitative assessment may be largely subjective, hence the need to integrate or substitute by more quantitative-based methods that are currently used in the literature.

There are several methodologies currently used in the literature to obtain index or monetary values for the aesthetic or visual amenity value of landscape:

- The most relevant UK study combined survey and hedonic price methods (Mourato et al, 2010) as part of the UKNEA. It calculated the marginal value to health and emotional wellbeing of having a view of nature compared to no view of nature at £350 per person per year (for views enjoyed by residents). The range is from £161/person/year to £539/person/year (all 2017 prices). Mourato et al. ran a survey in 2010 to estimate the physical and mental health effects associated with UK broad habitats, domestic gardens, managed areas and other natural amenities. In the survey, respondents had to state in a scale 0-100 what was their level 'physical functioning' and 'emotional wellbeing'. Then, GIS was used to add variables such as landcover, and over 1 million properties transaction was analysed. The hedonic regression determined that having a view of green space from one's house increases emotional well-being by 5% and the general health utility score by about 2%. At this point, they calculated a preference-utility score based on the scores of 'physical functioning' and 'emotional wellbeing', which was used to generate Quality Adjusted Life Years (QALYs) associated with the environmental changes of interest. The authors highlight that the associations they have estimated cannot be interpreted as causal effects, and that the monetisation has been "tentatively assigned". Thus, they note that these figures are indicative only and subject to many assumptions as described above and should therefore be treated with caution.

- Van Berkel and Verburg (2014) conducted a survey with tourists in the municipality of Winterswijk (Nederland) to measure appreciation of recreation, aesthetic beauty, cultural heritage, spirituality and inspiration in the landscape, not just recreation values. Increased residential infill, the removal of landscape elements for improved agricultural production and rewilding due to agricultural abandonment were simulated. Complementary to this estimate, a travel cost estimate of the value of landscape service was done based on respondents' travel time to reach the region. The monetary value of the cultural services is placed between €86 (WTP) and €23 (travel cost) per tourist/year. Both of these studies give aggregate values, so do not directly apply to a marginal change in the quality of an individual's view of nature as a result of a transport scheme.

- A growing body of the literature is using photo-based surveys to elicit respondents' preferences (Schirpke et al. 2016, Southon et al. 2016) or willingness to pay for landscape indicators, e.g. presence of heritage elements in the view (Tagliafierro et al. 2016). It is noted that analysing relative preferences for landscape attributes between a choice experiment with and without a price attribute gives different results on people's preferences (van Zanten et al. 2016). It is worth noting the use of Photoshop to perform photo manipulating depicting likely landscape changes (Van Berkel and Verburg 2014). Schirpke (2016) and Southon (2017) are examples of recent papers using photo-based survey to elicit preferences about aesthetic values of landscapes, but neither identifies monetary values.

- Estimating aesthetic and recreation values of landscape using geotagged photos. Recently, studies have used geotagged photos on social networking services instead of survey results of user preferences (Yoshimura and Hiura 2017, Figueroa-Alfaro and Tang 2017). The methods used in these studies were cost effective and provided spatially explicit results, although there is the concern that the subset of population posting pictures online is not representative. In fact, it depends on the rate of internet use, cameras with GPS, and mobile phones in a region. Which are correlated with age, education, ability or motivation to use social network services. Finally, these methods do not provide monetary values, and have yet to present a valuation methodology compliant with economic theory, they can be interpreted as a measure of aesthetic demand and potential supply of landscape value.

- Tagliafierro et al. (2016) develop a method for valuing, in monetary terms, landscape components represented by visual indicators using a stated preference technique. Their methodology is supported by a thorough use of landscape ecology metrics and methods: they geo-referenced 332 photographs covering the whole study area to quantify the landscape characteristics through landscape concepts and visual indicators. Those indicators were subsequently used as explanatory variables – landscape attributes – in the environmental economics model to explain the answers to the contingent valuation questions. Preference and WTP data were collected with an in-person 20 min survey administered to a sample of 601 residents of the seven municipalities of the Peninsula of Sorrento (Italy). In the survey, respondents were asked to choose between two alternatives. The first alternative was represented by a photograph of the actual landscape and a value of the tax to implement a policy to maintain landscape in the same conditions as depicted in the photograph. The second alternative, corresponding to the status quo, involved no intervention to protect the landscape and no payment of any new tax. This approach used a landscape typology from a parametric method and GIS-techniques (Van Eetvelde and Antrop, 2009) to identify landscape types.

- Hedonic pricing using spatial data. Using GIS data and hedonic pricing could provide an estimate of WTP for landscape quality. For instance, Schläpfer et al. (2015) estimate the impact on Swiss housing prices of distance to roads, distance to highways, forest, diversity, distance to view, lake distance, lake view, river distance, urban parks, hiking trails etc. Schläpfer et al. (2015) is notable for its large dataset (162,523 apartments). Regarding aesthetic values, they estimate a lake view to increase an apartment price by 2.7%, but other environmental amenities have very little impact or even unexpected signs for their coefficients. Note this method may also capture values of other (non-aesthetic) environmental qualities, such as air quality.

- Using travel cost method for estimating the value of landscape aesthetics. An example is given by Van Berkel and Verburg (2014), who used both travel cost method and photo-based contingent valuation method to provide a valuation of cultural ecosystem services in an agricultural landscape in the Netherlands. This was linked to respondent appreciation of the landscape functions of recreation, aesthetic beauty, cultural heritage, spirituality and inspiration. They found that the monetary value of the cultural services is placed between €86 (WTP) and €23 (travel cost) per tourist/year.

- Using GIS resources to generate high-resolution indices of landscape values: For example, Swetnam et al (2017) selected 19 landscape components commonly found to influence landscape quality ratings (e.g. presence of waterfall, habitat richness, number of plants, and human presence). Using vegetation surveys and GIS datasets each component was measured and assigned a numeric value based either on presence or quantity and/or extent for 150 1km^2 survey sites across Wales. Totalling these values, then scaling and weighting them provided a visual quality index (VQI) for each site between 0 and 1. Each site was then evaluated for a range of potential users (pedestrians, cyclists, car users) to calculate a modelled viewshed (ZVI). By combining the VQI and the ZVI, they capture two elements: firstly, the intrinsic landscape quality (its aesthetics) and secondly, how much of the landscape can be seen by the public in order to enjoy the view.

- Paracchini et al. (2016) presented a novel framework to measure societal demand for agricultural landscapes, combining a landscape awareness indicator with more physically based assessments, which include the impact of human activities on landscapes. Loures et al. (2015) analysed the aesthetic quality and economic valuation of the Lower Guadiana river landscape (between Spain and Portugal), through the application of direct and indirect landscape evaluation methods. The obtained results showed that there are significant differences between the perceptions of the general public and expert analysis.

Measures like the VQI have the potential to give an indication of landscape impacts. They are not a substitution for landscape assessment. However, it is not regarded as capable of replacing landscape assessment as a whole, as the presence/ quantity/ extent of features do not fully capture the spatial relationships between features that produce a landscape's quality (in particular a landscape of high scenic quality) and Swetnam et al acknowledge this.

Others hold more fundamental objectives to scoring approaches. The evolution of Landscape Character Assessment was in part inspired by disillusionment with attempts to quantify landscape value. Swanwick (2002) summarised this concern that "*many believed it inappropriate to reduce something as complex, emotional and so intertwined in our culture, as landscape, to a series of numerical values and statistical formulae*." However, without any quantified measures, interpreting and weighting landscape assessment evidence is left to the discretion of decision-makers.

In general, when assessing different aspects of landscape using GIS data, it is inevitable that proxies representing the actual features will be used. Some aspects of landscape are likely to be under-reported, such as the significance of tree groups or linear features in defining landscape character. It would also be important to be clear if any metric is capturing landscape quality, scenic quality or landscape value (landscape quality and scenic quality are subsets of landscape value – see Figure A1.2). Approaches such as in Swetnam et al. are considered most suited to appraising the visual amenity of 'scenic quality' rather than the wider concept of 'landscape value'.

An approach which considers the visual amenity of 'scenic quality' rather than the wider concept of 'landscape value' will help avoid difficulties which might arise with assigning a low scenic quality rating to a currently designated landscape. Swetnam et al recognise that the indicators used cannot capture all aspects of landscape value.

Overall, no new monetary valuation evidence suitable for appraisal of UK landscape impacts has been identified.

2.4 Air Quality

The current UK Government methodology (Defra, 2011) for appraisal of local air quality impacts due to infrastructure projects considers NO_2 and PM10 concentrations and numbers of properties affected (using GIS). Appraisal of regional air pollution considers only oxides of nitrogen (NO_X) and carbon dioxide (CO_2). Economic valuation of air pollution uses a hybrid approach which combines the damage cost and marginal abatement cost (MAC). The values are given by the TAG data book and were estimated by Defra and the Interdepartmental Group on Costs and Benefits (IGCB) in 2006.

Detailed modelling of vegetation's role in mitigating air quality damage has recently been undertaken in the UK to include national pollution removal in ecosystem accounts (Jones et al, 2017). This report estimated that in 2015 UK vegetation removed 21,800 tonnes of PM2.5, 75,900 tonnes of SO_2, 77,400 tonnes of NO_2 and 1,179,000 tonnes of O_3. In 2015 alone, there were 1,900 avoided deaths, 27,000 avoided life years lost, 5,800 fewer respiratory hospital admissions and 1,300 fewer cardiovascular hospital admissions due to this air pollution removal by UK vegetation. The economic value arising from these avoided health costs was estimated at over £1bn in 2015.

Jones et al (2017) used modelling of pollutant sources, land cover, climatic dispersal human population exposure and subsequent health effects. From this modelling, data was also developed to reflect the proportion of the service provided by different types of vegetation in urban areas (for the UK urban natural capital accounts, eftec et al, 2017) and for woodland habitats.

Using this data, the following breakdown of the Jones et al's modelling results can be made:

- The surface area of the UK is 24.90m ha, or which 1.77m ha are the extent of the urban natural capital account.
- Of these 0.10m ha are urban woodland, and 2.79m ha are non-urban woodland.
- The total value of air pollutant removal by vegetation in the UK is £1,006m per year, of which £736m/yr is by woodland.
- The models estimate that £212m worth of air pollutant removal is by vegetation in urban areas, and £206m is by urban woodland.
- The remaining £794m/yr is in non-urban areas, and of this £530m/yr is by woodland.
- Thus the value per ha for urban woodland is £2,072 per yr. Other habitats in urban areas provide a service worth £3.6 per ha per year, this is low because the majority of this other habitat is managed grass for playing fields and public parks.
- In non-urban areas, the service provided by woodland is estimated at £190/ha per year; and by other habitats £13/ha.

This simple interpolation of the figures from Jones et al derives the average per hectare values for woodland and non-woodland habitats in urban and non-urban areas, as shown in Table 1.2. They show a very large range, illustrating the variability in the value of this ecosystem service in different locations. However, these figures are the result of comparing different versions of the modelling conducted by Jones et al (2017) so are only indicative values.

Table A2.2: Indicative Annual Values for Air Pollutant Removal per ha of Vegetation Estimated from Jones et al (2017)

£/ha/yr values	Urban	Non-urban
Woodland	2,072	190
Non-woodland	3.60	13

As well as annual values, Jones et al (2017) also calculate asset values for the provision of air pollutant removal benefits by vegetation into the future. The benefits in future years are not constant, for reasons such as expected declines in the volume of air pollution. A similar process using the asset values provides the following indicative asset values. They are calculated over 100 years using recommended declining discount rates from the HMT Green Book guidance applied in 2017.

Table A2.3: Indicative Asset Values for Air Pollutant Removal per ha of Vegetation Estimated from Jones et al (2017)

Asset values (PV £/ha)	Urban	Non-urban
Woodland	40,080	3,448
Non-woodland	69	235

The values derived from Jones et al (2017) were devised to provide evidence for the UK national accounts. With further work they could be refined to provide more robust and locally-relevant marginal per ha values for the removal of air pollutants by vegetation that would be suitable to use in transport scheme appraisal.

The following examples illustrate the application of a wide variety of valuation methods to air quality impacts across the world. However, none provides monetary values that are suitable to improve the current method and estimates in Table A2.2 for appraisal of transport schemes in the UK – mainly due to the differences in socio-economic and environmental conditions across the countries.

Avoided health cost approaches have been used to value air pollution impacts in other countries:

- Galvis et al (2015) used avoided health costs (in a similar manner to Jones et al) to evaluate the benefits of an infrastructure project in Atlanta (US). They found that reductions in PM2.5 concentrations due to converting switcher locomotives to lower emission technologies might save approximately $20 million in annual avoided health costs and premature mortality. The measure has a positive NPV of about $140 million dollars through the ten-year period implementation.

- Chen et al. (2017) provide another example of valuing the benefit of a policy reducing PM2.5 concentrations via avoided health impacts. They estimated a WTP of about 0.01-0.8% of GDP for a pollution reduction project in China.

Willingness to Pay for air quality could be also estimated by household locational choices in Indonesia (Tan 2017), and Filippini and Cruz (2016) use contingent valuation to estimate annual average WTP to improve air quality in Mexico City. Similar studies have been undertaken in Europe, including the UK. For instance, Istamto et al. (2014) used contingent valuation to estimate WTP to avoid health risks from road traffic related air pollution and noise across five countries. The mean WTP estimates to avoid air pollution effects in the UK were: €104 per person per year (pp/y) for general health risks, €87 pp/y for a half year shorter in life expectancy, and €343 pp/y to a 50% decrease in road-traffic air pollution.

Other studies have analysed the correlation between life satisfaction and pollution. For example, Ambrey et al's (2014) study in Queensland, Australia estimated individuals' willingness to pay for a one day decrease in the average number of days PM10 concentrations exceed national health guidelines.

2.5 Noise Regulation by Vegetation

The UK's urban natural capital account (eftec et al, 2017) includes a pilot study in 2017 for the present value of this ecosystem service in Greater Manchester. It valued reduced exposure to noise of 1 and 2 dB above a threshold of 55 dB. These values are also used in other literature. Ising and Kruppa (2004) identify evidence of disturbances resulting from environmental noise from a level of 42dB(A) (outside) in the "Noise and Health" report of the Health Council of the Netherlands (1994). Jansen and Notbohm (1994) quote a range 45-55 dB(A) as the threshold for reactions by the population (based on a disturbed contingent between 0 and 20% of the population). Ortscheid and Wende (2000), in their assessment of flight noise based on currently available literature, come to the conclusion that the boundary to substantial disturbance is reached with a flight noise of 55 dB(A) in the daytime and 45 dB(A) at night (outside).

The current methodology for appraisal of noise impacts should be carried out using the Calculation of Road Traffic Noise (DoT, 1988) and the Calculation of Railway Noise (DoT, 1995) as standard prediction methodologies. Modelling aviation noise is undertaken using the ANCON model. Taking noise impacts, Defra's noise modelling tool[13] uses dose-response functions for each impact pathway, for road, railway and aviation noise. The approach uses the UK government economic valuation guidance on noise exposure (decibel reduction) from road (also includes rail and aviation) to estimate monetary values (Defra, 2014; Nellthorp et al, 2005). Monetary valuation of changes in noise is based on estimation of the number of Disability-Adjusted Life Years (DALYs) lost (or gained) under each impact pathway, and monetisation with a current value of £60,000 per DALY.

Work for Defra led by eftec involving modelling by the Centre for Ecology and Hydrology of noise regulation by trees provided further valuation research for this service in urban areas of the UK in June 2018. This suggested the value of the service was lower than previously estimated. The service is only provided by trees that are part of a block of canopy of over 200m^2 that mitigate noise exposure to households within the city. Some areas of trees may not provide this service (zero value) whereas others will provide it at a higher value per ha.

Alternative UK evidence is Day (2010)[14], which valued noise impacts from air, road and rail traffic in Birmingham, UK. It found the marginal value of a decrease in noise increases with background noise levels. The benefit of a 1 dB decrease in road and rail noise per property range from £31.49 and £83.61 (from a base of 56dB) to £88.76 and £137.41 (from a base of 80dB).

The results using DfT guidance can be compared with other methodologies used in the literature. Bristow et al (2015) compiled a meta-analysis based on a data set of 258 values from 49 studies and 23 countries and spanning more than 40 years. The list of value per dBA could be used as a reference, as well as their meta-model. The meta-model values are somewhat higher than the WebTAG values but are broadly similar in terms of relativities between noise levels. E.g. the model forecast a mean value of £126 (2010 value) per household per annum per dB for a noise level greater than 65 Db, compared to £93 in WebTAG.

[13] https://www.gov.uk/guidance/noise-pollution-economic-analysis
[14] Day, B. et al. (2010) "Estimating the Demand for Peace and Quiet Using Property Market Data", Centre for Social and Economic Research on the Global Environment, School of Environmental Sciences, University of East Anglia.

On transport-related disamenity effects, there is solid evidence that aircraft noise depreciates property prices (Ahlfeldt & Maennig, 2015; Boes & Nüesch, 2011; J. P. Nelson, 2004; Pope, 2008). In similar fashion, high environmental quality, e.g., clean air or water, is typically associated with positive capitalization effects (Harrison & Rubinfeld, 1978; Leggett & Bockstael, 2000; J. P. Nelson, 1978), as are unspoilt natural spaces (Gibbons, 2015; Tyrväinen & Miettinen, 2000). The literature is sparser and less conclusive, however, on the capitalization effects of rail noise. Still, there is some evidence suggesting that rail may have negative property price effects at a highly localized level, possibly due to noise (e.g. Al-Mosaind, Dueker, & Strathman, 1993; Debrezion, Pels, & Rietveld, 2010; A. C. Nelson, 1992).

A new method to measure willingness to pay to reduce road noise annoyance is found by Bravo-Moncayo et al. (2017), who use an artificial neural network (ANN) ensemble. They estimated a WTP to reduce road annoyance of $12.90 using a probit model, and $15.70 using ANN in a case study is in Quito, Ecuador.

Other recent studies use hedonic pricing (Łowicki, and Piotrowska 2015, Schläpfer et al. 2015). Łowicki, and Piotrowska (2015) conducted a case study in Poland and found that plots located in the zone with noise exceedance at night were about 57% cheaper than those located outside this zone (Poznam, about 500 observation). Schläpfer et al. 2015 found that for each DBA coming from road traffic (given DBA>40[15]) housing prices decrease by 0.2% (Switzerland, 162k observations).

Furthermore, contingent valuation methods are used to estimate the WTP for noise annoyance. The above-mentioned that the Ambrey et al (2014) study estimated a mean WTP to avoid road traffic noise effects in Queensland, Australia of: €76 pp/y for general health risks, €70 pp/y for a 13% increase in severe annoyance, and €344 pp/y for a combined-risk scenario related to an increase of a noise level from 50dB to 65dB.

As with the Jones et al (2017) modelling of air quality regulation by vegetation, the current study is likely to provide values that can be used as a starting point for attributing per ha values to this service in transport appraisal.

The Day et al study and the method from eftec (2017, current being extended) offer potential to specifically value noise mitigation by vegetation in the landscape category in WebTAG. Both will be further assessed in the case studies.

2.6 Recreation

A number of ways that transport schemes can impact on recreation values for the environment are identified in WebTAG:

- Direct loss of formal recreational areas and/or loss of amenity value of formal recreational areas;
- Severance of (public) rights of way and/or loss of amenity value of rights of way, and
- Direct loss of public open space/common land and/or loss of amenity value on open areas.

[15] A typical approach in assessment and appraisal is to define ‘tranquillity’ as noise levels below 45 decibels.

There are numerous economic valuation studies of recreation. This review focuses on two major studies in the UK: the ORVal Tool developed by the University of Exeter, and the UK national ecosystem assessment values and associated modelling by Sen et al. (2011). They are mainly relevant to transport appraisal as a way of estimating lost recreation opportunities as a result of building transport infrastructure on previously accessible green space.

Using ORVal is considered preferable to the Sen values, as ORVal is a more sophisticated economic model, accounting for substitutes and site habitats, and is able to predict visitor numbers to sites. It is also consistent with valuation approaches in WebTAG that use the value of time. As ORVal takes into account substitute sites, it is suitable for valuing the total loss of a recreation site and provides a baseline for valuing a marginal change to a recreation site.

The advantages of the Sen values are to apply where the numbers of visitors are known. This may be relevant for a site with special characteristics which mean its value may be less accurately predicted by ORVal.

2.6.1 ORVal

The Outdoor Recreation Valuation Tool (ORVal) (University of Exeter, 2017) is an online tool that has been developed for Defra to estimate the recreational use (visit numbers) and value (£) of open access green space sites in England and Wales.

The estimates reported by ORVal are based on a statistical analysis of the Monitor of Engagement with the Natural Environment (MENE[16]) survey. The MENE survey is a large, random location sample[17] of recreational day trips to the natural environment taken by adult (over 16 years of age) residents of England. The details of those trip choices have been used to estimate a sophisticated recreational demand model which is able to predict the number of trips that might be taken to each different recreational site and the welfare value that those trips provide to visitors (disaggregated by socio-economic group). This model accounts for the following determinants of an individual's choice of recreational site (Day and Smith, 2017):

- Travel cost: the time and money invested to visit this site - calculated based on the time and travel costs that would have been incurred by a respondent in travelling to and from each recreational greenspace included in their choice set;
- Greenspace type: such as woodland, coastal, rivers, agriculture, saltmarsh, moors, natural grassland etc.;
- Size and land cover composition: including a measure of land cover diversity for each site;
- Commonalities with other greenspaces (i.e. common boundaries, overlaps in path networks);
- Designations given to the recreation site (e.g. National Park, Historic Park, Natura 2000 site, Ramsar site, SSSI);

[16] https://www.gov.uk/government/collections/monitor-of-engagement-with-the-natural-environment-survey-purpose-and-results
Fieldwork started in March 2009 with around 800 respondents interviewed every week (giving at least 45,000 interviews/yr) across England using an in-home interview format.

[17] Gathered consistently since 2009.

- Points of interest available at the recreation site (e.g. historic building, scenic feature, playground, viewpoint);
- Timing of trip: year, month and day of the week when the trip is taken;
- Location of residence: region of England and whether the residence in an urban or rural location
- Socio-economic information: respondent's age, gender, whether they have children, working status, socio-economic status (i.e. A, B, C1, C2, D, E) and dog ownership.

The theoretical underpinning of the ORVal recreation demand model is provided by the random utility framework (McFadden, 1973). This framework characterises recreational decisions as discrete choices where, on each choice occasion, an individual must decide whether to make a trip to an outdoor greenspace and if so select which particular site to visit from the diverse array of sites providing opportunities for outdoor recreation. The ORVal model takes each day as a separate choice occasion and models individuals' evaluation of each site as being a trade-off between the benefits that might be enjoyed from spending time at that site and the money and time costs of travelling to and from that site. An individual is assumed to visit the site for which those net benefits are greatest. Put simply, the model examines the recreational trips observed in the MENE survey and uses the costs individuals incur in travelling to their chosen site to infer the value provided by that greenspace and, more particularly, how that value varies according to the different characteristics of that site.

The ORVal model builds on the dataset used in a methodology for spatial- and ecosystem-sensitive estimation of recreational visit numbers and their values across Great Britain presented by Sen et al (2014). Drawing upon an extensive and spatially explicit survey of current recreational behaviour, data were combined with highly detailed information on population characteristics, transport infrastructure and GIS generated measures of the availability of potential substitutes and complements.

Both ORVal and the Sen et al model are considered to have potential to contribute to appraisal of recreation impacts of transport projects. However, the modelling involved inevitably means that the predictions come with some important caveats. For example, ORVal is not able to account for potentially important idiosyncrasies of particular parks or open spaces. As an example, the model's predictions of visits and values are based on the areas of different habitats and the extent of different water features available at that site but it does not account for the fact that a particular park may have habitat or water features of particularly low or high quality. Likewise the model adjusts values for the presence of a site of historical/archaeological interest but clearly such sites can be of greater and lesser interest and again the model is not capable of distinguishing the impact of such differences.

In general, ORVal is recommended as a consistent starting point for data to assess the impacts of transport schemes. The loss of a hectare of accessible land can be directly estimated according to its total welfare value in ORVal. Illustrative values from ORVal for recreation sites in the different land categories used to value Landscape in the supplementary VfM guidance (See Table A1.1) are shown in Table A2.4. The values are rounded to 2 significant figures, reflecting the uncertainty in the estimates. No values are presented for agricultural land as, such land is not typically a visitor 'site' of the type identified in ORVal. However, it may be possible to value impacts on footpaths within agricultural land, and this will be investigated further through the case studies.

The ORVal model reflects the fact that recreation values vary significantly with a number of factors, in particular location (and proximity to resident populations and substitutes), as well as habitat type. Therefore, accurate representative per ha values cannot be reliably be generated for habitat types alone, but also need to reflect urban/rural locations as shown in Table A2.4 Representative values for these land types still have significant uncertainty, as the size of the urban area (for urban core and urban-fringe) can vary. However, generating values in ORVal is a low-effort activity. It is estimated to require:

- Reading the ORVal guidance (1-2 hours);
- 30 minutes of training on the software; and
- Less than 5 minutes per site to obtain values.

Therefore, site-specific values could be obtained from ORVal for most transport appraisals considering the complete loss of accessible open spaces or footpaths.

Table A2.4: Example recreation values form ORVal for different landscapes

Land Type	Present Value per ha (£) (2017 prices, 100yrs)	Examples
Urban core	1,000,000	Logan's Meadow, Cambridge
	1,800,000	Hampstead Heath, London
Urban Fringe (greenbelt)	129,000	Old Sodbury Common, Glos
Urban Fringe (forested land)	600,000	Upton Court Jubilee Wood[1], Slough
	100,000	Forest of Marston Values[1], Beds
Rural forested land (amenity)	12,000	Cwm Fagor[1], Monmouthshire
	12,000	Drumlanrig[1], Dumfries and Galloway
Agricultural Land (extensive)	-	
Agricultural Land (intensive)	-	
Natural and semi-natural land	94,000	Pegsdon Hills, Beds

Notes: 1: source (eftec, 2016). Values for Welsh and Scottish sites were not directly estimated from ORVal.

As mentioned above, the main weakness of ORVal is in relation to recreation sites with unique characteristics (e.g. such as cultural significance or visitor facilities[18]) which are hard to reflect in a spatial model. For such sites, ORVal estimates have higher uncertainty. Where known, site visitor data is better to use than ORVal estimates. They can be multiplied by the per-ha values from Sen et al (2014) for the most relevant habitat type shown in Table A2.3.

Using ORVal is generally preferable to the Sen values, as ORVal is a more sophisticated economic model, accounting for substitutes and site habitats, and is able to predict visitor numbers to sites. It is also consistent with valuation approaches in WebTAG that use the cost of time (See Box A2.1). The advantages of the Sen values are to apply where the numbers of visitors are known. This may

[18] The assessment of transport impacts on such sites may require an impact assessment beyond the standard application of WebTAG.

be relevant for a site with special characteristics which mean its value may not be accurately predicted by ORVal.

A further complication is where a transport scheme impacts recreational value indirectly. For example, this might be due to recreational area being affected by the visual intrusion or noise from an adjacent or nearby transport scheme. This would be expected to cause a marginal change, rather than a complete loss of the recreational value of that land. This change is hard measure and value, with several options being available:

i. ORVal can be used to investigate these changes, as the types of habitat at a site can be varied in the Tool. These variations can be used as a proxy for variations in site quality. However, this approach is untested, and it is highly uncertain whether changes in habitat types are an acceptable proxy for the impacts of adjacent transport infrastructure on the benefits of accessible land for recreation.

ii. Where a change in the number of users of a site can be established (either by survey or estimated), the reduction in visits can be valued according to the Sen et al values in Table A2.3.

iii. Alternatively, where a change in visitor numbers is established, this can be used to assess the percentage change in the user numbers at a site (either by comparing to a known baseline or the estimated baseline in ORVal). This percentage reduction in value can then be applied to the total value identified in ORVal to give an estimated change in value[19].

It should be noted that for ii) and iii), a survey to establish the change in visitor numbers would be a costly and uncertain exercise (since pre-scheme responses might not represent actual behaviour) and an estimate of expected change based on expert judgement would have high uncertainty (unless guided by data on relevant actual experience from completed projects).

[19] This change in value will reflected by a range of factors including site features (e.g. size, land cover) and other factors (e.g. substitutes). The impacts of transport schemes on these factors is discussed in Section 5.2.2 of the main project report.

Box A2.1 Comparison of time valuation in ORVal and WebTAG

Current values in the TAG Data Book are based on research conducted by the Institute for Transport Studies (ITS) and Accent for the Department for Transport, reported in 2015, and published as 'Provision of market research for value of travel time savings and Reliability: Phase 2 Report'[1]. These values were also used by ORVal, as shown below:

Summary of relevant values used by ORVal		
Type of cost	**Cost**	**Source**
Cost of fuel per car	9p per km (2014 prices)	AA motoring cost publications[1]
Cost of time spent travelling for non-work activities. Trips under 8Km	£2.30 per hour (2014 perceived prices)	Department for Transport 2015[1]
Cost of time spent travelling for non-work activities. Trips between 8km and 32km	£3.47 per hour (2014 perceived prices)	
Cost of time spent travelling for non-work activities. Trips between 32km and 160km	£6.14 per hour (2014 perceived prices)	
Cost of time spent travelling for non-work activities. Trips greater than 160km	£9.25 per hour (2014 perceived prices)	

The methods DfT (s015) study methods were focused around Stated Preference (SP), but complemented by Revealed Preference (RP) as a validation device. The SP experiment types were: (1) Time vs. cost, (2) Time vs. cost vs. reliability, (3) Time vs. cost vs. quality. The results have also been re-weighted using data from National Transport Survey (NTS). The final model is presented in an Implementation Tool, which creates a sample enumeration system based on the National Travel Survey (NTS), which can estimate mean values of time, reliability and crowding etc. for selected aggregations of the travelling population, for any chosen model, as well as the confidence intervals associated with those values.

As a result, estimates of value of travel time (VTT) are available for several combinations of purpose (employees' business, commuting, other non-work), mode (car, bus, rail, other PT), and distance. The following table summarizes the main estimates of VTT for non-work travels. The values are in pounds per hour (perceived prices).

	All distances	<5 miles	5-20 miles	20-100 miles	>=100 miles
All modes	5.12	2.30	3.47	6.14	9.25
Car	4.91	2.15	3.36	5.97	9.08
Bus	3.26	3.10	3.27	3.71	n/a
Other PT	5.23	5.62	5.15	n/a	n/a
Rail	8.68	6.53	6.44	8.06	10.01

2.6.2 Sen et al (2014) and UKNEA

Sen et al. (2014) developed a trip generation function (TGF) which analyses the number of visits to a given site as a function of the characteristics of the outset (where the trip starts from) location (including population socioeconomic and demographic characteristics, the availability of potential substitutes, etc.), travel time to the destination (taking into account the road network and its variable quality) and characteristics of the destination site (including its ecosystem type, the availability of surrounding potential substitutes and complements, etc.). The function was developed using the data from the long-running Monitor of Engagement with the Natural Environment (MENE) survey administered by Natural England. The resulting function was then used to predict the number of visits per week to all 1 km square cells across the current land use of Great Britain.

In the second step of their analysis, they seek to determine the value of predicted visits. For this purpose, they develop a trip valuation meta-analysis model. This step of the study analyses nearly 300 previous estimates of the value of a recreational visit, examining the determinants of those values which include the influence of the ecosystem type of visited sites.

This allows the authors to estimate value of recreational visits to each type of ecosystem and for the current land use and the future land use described under any given UK NEA scenario, i) the number of visits to each 1km cell across Great Britain (adjusted for location, ecosystem type, road network, population distribution and characteristics and the availability of substitutes and complements); ii) the value per visit for that cell (adjusted for the ecosystem type specified under that chosen scenario) and, by drawing these together, iii) the spatially and ecosystem sensitive total value of visits and how that value varies from that obtained under current land use. The values are in a range of £2 - £6 per visit, depending on the habitat types visited, as shown in Table A2.5.

Table A2.5. Recreation Values per visit from Sen et al. (2014)

Greenbelt and urban fringe farmlands	£/person/trip (2017 prices)	6.02
Mountains, moors and heathlands		5.65
Marine and coastal		4.45
Woodlands and forests		3.75
Freshwater and floodplains		2.05
Grasslands		1.73

2.7 Carbon

Where transport projects develop a hectare of natural habitat they will result in the loss of the carbon stored in that habitat. Habitats with the highest stores of carbon in the UK are woodlands and peat soils. Peat habitats occur mainly in remote upland areas, which are less likely to be developed for transport projects. Lowland peat habitats that are in good condition (i.e. still wet) are generally protected for nature conservation reasons. Dry peat soils (e.g. that have been drained for agriculture) are sources of carbon emissions (as the stored carbon oxidises), and are no longer a long-term carbon store. Further work could be undertaken to examine carbon emissions for peat habitats as a result of transport projects, but it is not regarded as a priority for this study.

Loss of woodland is a more realistic potential impact from transport projects. Its implications for carbon emissions are that the carbon stored in the woodland may be omitted (depending on the use of the timber), and future sequestration by the woodland may be lost.

The stock of carbon in UK woodlands varies with woodland type and environmental conditions. eftec et al (2014) estimated that in 2012 UK woodlands held 213 million tCO_{2e} across 2.78m hectares of woodland. This gives an average of 77t per hectare, which at current carbon prices (the central non-traded price for 2017 is £64 / tCO_2e) is approximately £5,000 per ha.

For loss of future sequestration, the ONS (2016) estimates of carbon sequestration across the UK woodland area, can be interpreted, assuming a proportional approach based on the estimated area of woodland within UK urban areas. Therefore, this is a crude approach based on average tree size and carbon sequestration factors. Based on a UK average of 5 tCO_{2e} sequestered per ha per year, the capitalised average value, over 100 years, of urban woodland (most likely to be impacted by transport projects) is £24,400 per ha.

The combined value of current carbon stored in woodlands and forgone future sequestration of emissions is estimated at approximately £30,000 per ha.

2.8 Other Evidence for the Supplementary VfM guidance Land Types

In addition to the key services from the supplementary VfM guidance land types (shown in Table A1.1) there are other sources of evidence relevant to the valuation of landscape in WebTAG.

2.8.1 Urban Habitats

A UK urban natural capital account was published in 2017 (eftec et al, 2017). This report defines urban natural capital in and around developed urban areas, and therefore covers both the urban core and fringe distinguished in Table A1.1. As a result, its data cannot be broken down between those two categories.

Nevertheless, it indicates the highest-value ecosystem services, based on known evidence, for urban natural capital:

- Welfare associated with recreation, and the avoided health costs as a result of physical activity (which are additional to recreation) are the main values making up approx. 70% of the total value identified. The health benefits are only partially valued, and are potentially equal to or larger than the recreation welfare values described from ORVal in Section 2.6.2.
- Important values are also identified for food production (from allotments), carbon sequestration, and noise, heat and air quality regulation by vegetation.

There are other approaches to valuing ecosystem services in urban areas. The i-Tree software (USDA Forest Service[20]) has been adapted to measure ecosystem services from urban trees in the UK (e.g. Scott et al 2016; Baró, 2014). i-Tree combines meteorological and air quality data with information collected about an area's trees (i.e., number, size and species) to determine the benefits through carbon sequestration, air quality and flood alleviation. It has potential to support detailed site-specific analysis of these values, but cannot generate 'look-up' style values to input to transport scheme appraisal.

[20] https://www.itreetools.org/

2.8.2 Habituation

An important assumption in valuation evidence (e.g. on noise) is that the annual values of services will continue into the future, thus supporting estimates of their present value based on standard public sector appraisal processes. There are many uncertainties in this assumption, from socio-economic factors (e.g. demographic change) that potentially affect several services, to service-specific factors such as preferences and technologies (e.g. electric vehicles may affect future noise and air pollution levels – if these decrease then there will be less value in vegetation being able to mitigate them).

A further factor over time is that the value of a service to an individual may change due to habituation effects. Ising and Kruppa (2004) found that under constant noise exposure the degree of disturbance remains unchanged, i.e. there are no indications as to people habituating to noise. Basner et al (2011) found in a laboratory study of exposure to rail, road, and/or air traffic noise events some evidence of short-term habituation (more sleep continuity most likely because of an increase in arousal thresholds). However, they observe that the degree of sleep disturbance found in field studies, i.e., after months or years of noise exposure, is usually much lower compared to laboratory studies. This suggests that habituation continues beyond the periods usually investigated in the laboratory.

This evidence is considered inconclusive.

2.8.3 Adjustment of house prices

A number of studies have analysed the property price effects of transportation infrastructure (e.g. Bajic, 1983; Baum, Snow & Kahn, 2000; Bowes & Ihlanfeldt, 2001; Damm, Lerner, Lam, & Young, 1980; Dewees, 1976; McDonald & Osuji, 1995; Voith, 1993). Recent applications focus, in particular, on the property price effects of transport innovations, e.g. improvements of a road or rail network, to achieve better identification (Ahlfeldt, Moeller, & Wendland, 2015; Billings, 2011; Hurst & West, 2014; McMillen & McDonald, 2004; Xu, Zhang, & Zheng, 2015). Overall, the findings suggest that transport infrastructures (and railways in particular) are typically associated with an increase in local property values.

On transport-related disamenity effects, there is solid evidence that aircraft noise depreciates property prices (See Section 2.5). Hedonic-pricing valuation using house prices is a complex undertaking and has uncertainties, not least due to trade-offs from the effects of transport infrastructure. For example, Ahlfeldt et al (2016) found that ceteris paribus, a 1 km reduction in distance from the nearest station increases land prices (house prices) by 21% (5%), while a 10 db increase in noise depreciates land prices (house prices) by 5% (1%). Furthermore, Kiel and McClain (1995) note that house prices respond to rumours of an undesirable facility, but that this effect changes over time.

3.0 Potential Valuation Approaches in WebTAG

3.1 Comparison of Supplementary VfM Guidance Landscape Values to Current Evidence

The values used in the supplementary VfM guidance (shown in Table A1.1) from the external benefits valued in DCLG (2006) were generated across a range of benefit categories considered in ODPM (2001). Table A3.1 compares the current valuation evidence for the supplementary VfM guidance land types to the indicative valuation evidence identified in Section 2 of this Annex.

The comparisons of values in Table A3.1 suggests that the valuations in the supplementary VfM guidance are higher than would be suggested by available valuation evidence for some land types (e.g. urban core). This is a tentative conclusion because:

- Indicative values are used.
- The supplementary VfM guidance figures also include values for Soil.
- The data highlight the important role played by recreation in valuing loss of undeveloped land to transport infrastructure. Given that avoided health costs due to physical inactivity are potentially of a similar order of magnitude, and are not captured elsewhere in WebTAG, the current values used in the supplementary VfM guidance may not be overestimates of the value from these land types to society.
- Where the the supplementary VfM guidance values are higher than the indicative values, this might reflect the visual amenity or cultural values of landscape that are not reflected in the comparison.

The robustness of values in the supplementary VfM guidance is reflected through their classification as ‘established’, ‘evolving’ or ‘indicative’ effects. The values in Table A3.1 are classified as follows:

- Recreation: *evolving*, with higher certainty for more typical and smaller sites.
- Air quality regulation: *indicative*, but with bespoke use of available modelling could become *established*.
- Carbon: *established* under BEIS approach to valuation of carbon emissions, although uncertainties remain in the quantification of carbon storage and sequestration in some habitats.
- Noise: *indicative*, with ongoing work, likely to become *evolving*.

The implications of these ecosystem service valuations for value for money reporting will be examined through the case study worked examples to inform the overall suggested approach.

The results in Table A3.1 represent values generated by a mixture of methods and in a mixture of units. The WTP estimates, representing the bulk of the literature, can be presented in three different units: WTP (i) per visit - to a site (from 'recreational' studies); (ii) per household and (iii) per hectare per year. Therefore, per visit and per household values needed to be converted into per hectare values.

Table A3.1: Comparison of the supplementary VfM guidance Landscape values for different landscapes and indicative UK valuation evidence

<table>
<tr><th rowspan="2">Land Type</th><th colspan="2">Present Value per ha (£m) (2017)</th><th colspan="5">Indicative ES Present Values (PV[a]) (2017) £/ha</th><th rowspan="2">Comparison</th></tr>
<tr><th>In VfM Guidance</th><th>Adjusted[a]</th><th>Recreation</th><th>Air quality</th><th>Carbon</th><th>Noise</th><th>Total (PV)</th></tr>
<tr><td>Urban core</td><td>16.8</td><td>8.2</td><td>1 - 1.8m</td><td rowspan="2">69 – 40,080</td><td>Low, except woodland</td><td rowspan="3">£0 - £200,000 for blocks of canopy > 200m²</td><td>1 – 2m</td><td>VfM values much higher</td></tr>
<tr><td>Urban Fringe (greenbelt)</td><td>0.28</td><td>0.13</td><td rowspan="2">0.1 – 0.6m</td><td>Low</td><td>0.1 – 0.6m</td><td>Similar order of magnitude, but large range in ES values</td></tr>
<tr><td>Urban Fringe (forested land)</td><td>0.84</td><td>0.41</td><td>40,080</td><td>30,000</td><td>0.1 – 0.67m</td><td>VfM value similar</td></tr>
<tr><td>Rural forested land (amenity)</td><td>2.1</td><td>1.0</td><td>12,000</td><td>3,448</td><td>30,000</td><td>?</td><td>0.45m</td><td>VfM value higher</td></tr>
<tr><td>Agricultural Land (extensive)</td><td>0.98</td><td>0.48</td><td>-</td><td>235</td><td>Low</td><td>0</td><td></td><td></td></tr>
<tr><td>Agricultural Land (intensive)</td><td>0.03</td><td>0.016</td><td>-</td><td>235</td><td>0 or negative</td><td>0</td><td></td><td></td></tr>
<tr><td>Natural and semi-natural land</td><td>2.1</td><td>1.0</td><td>94,000</td><td>235</td><td>Generally low</td><td>0</td><td>0.1m</td><td>VfM value much higher</td></tr>
</table>

Notes: a. Annual values are taken from VfM guidance. For this analysis they are converted to PV for 100 years using the HMT regular (not the health) declining discount rates and no income uplift to WTP.

3.2 Integrating natural capital and ecosystem services

There are a range of ecosystem services typologies used through the economic valuation literature in the UK. This is reflected in the different typologies used in ODPM (2001) study from which the supplementary VfM guidance numbers originated and the literature reviewed in Section 2 of this Annex. It also motivated the Natural Capital Committee to define the benefits shown in Figure A.1.3.

3.2.1 Ecosystem Services from ODMP (2001)/ DCLG (2006) used in the supplementary VfM guidance

The services valued in ODPM (2001) were used in the DCLG (2006) study. As shown in Table A3.2, some of the services considered were not in fact valued.

Table A3.2. Services valued for the DCLG (2006) study used in the supplementary VfM guidance.

Benefits reflected in one of more of the land category values used in VfM guidance from DCLG (2006) – see Table 3.1.	Other benefits considered in DCLG (2006) study but not valued
Recreation	Tranquillity
Landscape	Accessibility
Ecology	
Cultural heritage	
Hydrology	
Air quality and (local) climate regulation	

Table A3.2 shows that for the benefits considered in ODPM (2001), tranquillity and accessibility had no values identified. In addition, values were identified for soil formation, but in current classifications of benefits (e.g. by the Natural Capital Committee) this is considered an ecosystem function or supporting service, which has its values reflected in other benefits (e.g. aggregates, food, water regulation, ecology) and therefore should not be valued separately to avoid double-counting.

The values used in the supplementary VfM guidance represent a mixture of benefits: Recreation, landscape, ecology, cultural heritage, hydrology, air quality and (local) climate. Of this list, the following categories are appraised (qualitatively or quantitatively) elsewhere in WebTAG, which poses a risk of double-counting:

- Ecology (wildlife category of environmental capitals);
- Cultural Heritage (historic environment), and
- Hydrology (water environment).

Air quality and noise impacts of vehicles are also appraised elsewhere in WebTAG, but the impact considered here is the air pollution regulation function of vegetation, which is different. Thus there is no risk of double-counting in these services.

3.2.2 Using Ecosystem Services and Natural Capital in Valuation

Economic valuation can examine individual flows of benefit from environmental assets (and impacts on them) and can value the bundle of benefits from the environmental assets and these change over time. The latter is the core of the natural capital approach, which can provide a more thorough basis for assessing impacts because it examines effects on the ability of the environment to support benefits to people into the future. In practical terms this results in looking at the present value of benefits that the environment is expected to provide, in order to establish its value as an asset. These approaches are reflected in the PV data and indicative present values of services shown in Table A3.1.

The economic evidence examined does not look at the expected duration of landscape impacts. For most of the ecosystem services, including the services considered in Table A3.1, the loss is considered ongoing and permanent. No evidence has been found in the literature examined to support the idea that impacts on individuals reduce over time due to habituation effects (see Section 2.8.2). However, for landscape impacts, it can be the case that built infrastructure becomes part of the cultural landscape over time.

A range of reasons can be examined that may cause the valuation of ecosystem services and landscape impacts to change over time: for example, grow due to long-term income and population growth or reduce due to the benefits of the mitigation options. However, it is hard to make a conclusive case to adjust value over time based on predictions of socio-economic trends like population growth. Uprating of future values for ecosystem services that are considered normal goods could be applied using standard forecasts of income growth from Government, provided this is consistent with assumptions used elsewhere in the apraisal. The timings of future impacts (including impacts of mitigation measures) should be informed by a scheme's EIA. The uncertainties involved apply to many types of data used in the economic appraisal of transport projects.

The term 'environmental capitals' in WebTAG reflects this concept, but is now out of sync with the prevailing terminology of ecosystem services and natural capital in the environmental economics valuation literature. Furthermore the values used to reflect 'landscape' impacts in the supplementary VfM guidance represent a range of benefits (or a 'bundle' of services) from different types of land. Not all of these are necessarily closely associated with 'Landscape'. For example, values for recreation contribute to the high value attributed to 'urban core' green space (see Table A3.1). The level of recreation value in urban areas is understood to be more strongly determined by size of surrounding population and substitutes, compared to scenic or other qualities of the 'landscape' offered by the urban green space.

However, this situation is made complex by the need to appraise 'landscape' in terms of its aesthetic and other qualities captured in landscape appraisals. Furthermore, on examining the benefits that are represented by the landscape values in the supplementary VfM guidance, they overlap with some of the categorisations of environmental capital. For example, the value of urban core spaces may also reflect their role in regulating urban air quality.

3.2.1 Options to Adjust WebTAG

Any shift to base appraisal in WebTAG on natural capital, and/or using evidence on the values on individual services/benefits, or bundles of them, would result in a need to change the structure of the other environmental capitals in WebTAG. Before this is done, there needs to be a clear case that doing so would make improved use of evidence to appraise the environmental impacts of transport schemes more accurately and in a proportionate manner.

In summary, the landscape values in the supplementary VfM guidance reflect a bundle of services and may double-count with other parts of the environmental capitals approach but may also not fully represent what landscape professionals recognise as landscape impacts.

Two broad value transfer options are identified to adjust the supplementary VfM guidance landscape approach. Firstly, ecosystem services within the current supplementary VfM guidance landscape bundle could be valued separately. Secondly, a new bundle of values for different land types, reflected the current bundle of services in the supplementary VfM guidance landscape category could be estimated. These two options are compared to the current supplementary VfM guidance in Table A.3.3. The comparison considers the core questions for value transfer outlined in Section 1.2.1:

1. What is the good?
2. What's the change?
3. Whose values?
4. Which monetary value evidence?

The supplementary VfM guidance approach to landscape valuation could also use a third option, of primary valuation of the ecosystem services lost per ha of habitat developed. This is considered realistic across a range of (but not all) ecosystem services, but such a study would need to be coordinated across Government to provide maximum value to the public sector. Therefore, the option to generate new evidence is considered only for a value of landscape.

The definition of the good being valued would need to be determined in designing the research, but would aim to reflect the definition of landscape in landscape appraisal (see Section 1.2.1), rather than the current definition of the landscape appraisal category in the environmental capitals of WebTAG. To cover all aspects of this non-market good, primary research would need to use revealed or stated preference approaches for valuation of landscape. The potential to apply stated preference techniques was piloted by eftec (2007 and 2009) as described in Section 1.4.1. This suggests such research would be feasible to generate values for the adverse impacts on landscape of constructing different types of transport infrastructure.

Table A3.3. Options for Adjusting WebTAG Appraisal of Landscape

Question	Objective	Current WebTAG	Alternative 1: Separate Appraisal of Individual Ecosystem Services (Benefits) from Landscape	Alternative 2: New Ecosystem Services bundle
What is the good?	Landscape, in its full definition and variations Landscape professionals define it as the holistic result of a combination of natural and man-made features and uses. Economics / ecology sees it as a bundle of ecosystem services	The 'Landscape' category in WebTAG doesn't actually define the "Landscape" asset (meaning aesthetic and cultural value of landscape (as defined in planning guidance as a combination of features) or measure a change in landscape features or change between different types of landscapes measure).	Value individual ES from within the current landscape bundle where evidence exists. NB: other ES categories are assumed to be captured in market values for land (e.g. timber, food production, minerals). NB the ability to access recreation would be reflected in the use of the transport infrastructure, so can be excluded.	The combination of ES not in other parts of WebTAG, differentiated according to land categories as per current system.
What is the change?	Impact of transport schemes on the landscape, which is a function of: transport scheme, type of landscape, uses of that landscape and non-use values that could be associated with that landscape	WebTAG does measure the change but does that in a very generalised way defined only by the area around the transport structure. And doesn't even differentiate the size of that area depending on the type of scheme or type of landscape.	Loss of services per ha of land category impacted by transport infrastructure development, and for some services (e.g. recreation, visual amenity) on areas adjacent or nearby affected by presence of transport infrastructure.	
Whose values?	Residents and visitors and non-users further afield	The monetary values reflect types of land in terms of their proximity to developed land/ people, which is an important determinant of the value of several services (e.g. recreation, air quality and noise regulation, and therefore appropriate in many appraisal contexts). However, these	Aim to distinguish user (resident, visitor, passer), non-user.	

Question	Objective	Current WebTAG	Alternative 1: Separate Appraisal of Individual Ecosystem Services (Benefits) from Landscape	Alternative 2: New Ecosystem Services bundle
		values don't reflect non-use valued for less populated but culturally valued landscapes.		
Which monetary value evidence[21]		Uses monetary valuations of land from DCLG (2006) study that, in current language, captures a bundle of ecosystem services, which include landscape (as defined above) but also a range of other services (e.g. recreational amenity), including some that are at least partly covered in other parts of WebTAG (e.g. ecology (= biodiversity); cultural heritage (= historic environment); hydrology (= water environment) and soil that will be either captured in market values for land (in terms of minerals and agricultural value) or in other values supported (e.g. biodiversity). Overall there is high risk of double-counting between part of the DCLG values and other WebTAG categories (although as biodiversity is not given a monetary value this is a qualitative double-counting risk).	Reformulate bundle – remove double counting (ecology, hydrology, cultural), add carbon sequestration, and air and noise regulation by vegetation.	Collated £ value for bundle of ES per land category. Would require detailed desk analysis to model and generate lookup values.

[21] The comparison is effectively for a choice of value-transfer options, so the question is about which evidence to use, not which primary valuation method to choose.

Considering the options discussed above, there is a further variable to consider. It may be that suitable methods are complex and too costly (in terms of time or resource) to apply at the basic level of transport project appraisal.

However, there may be a threshold (i.e. minimum amount or value of impact) above which such appraisal effort becomes worthwhile. Therefore, the 'individual ES' option can be subdivided into an option to only undertake it above a certain threshold of physical or monetary impact.

This then gives five options to consider:

1. Current
2. Individual ecosystem services
3. Bundle ecosystem services
4. Individual ecosystem services over threshold
5. Landscape value transfer using new primary research results.

These options are not all mutually exclusive. Ten potential combinations of them are considered to give a realistic approach, as shown in Table A3.4. For reference, different options are labelled 1 – 5 as above. For reference, different combinations of them are labelled A-J. Black shaded cells indicate the option applied in each approach.

Table A3.4. Potential Combinations of Landscape Appraisal Approaches for WebTAG.

Combinations	1	2	3	4	5
A.	■				
B.	■			■	
C.	■		■		
D.	■			■	■
E.	■		■		■
F.		■			
G.		■			■
H.			■	■	
I.			■	■	■
J.	■				■

The potential combination of these approaches will be discussed further following the project case studies. A factor to be examined in testing option 4 is that once the bundle of ES is separated, individual values are needed for each relevant service. This may significantly increase the time/ costs, and/or reduce the accuracy of, the overall appraisal evidence.

Report for – Department for Transport
Valuation of Landscape Impacts of Transport Interventions & Mitigations Using an Ecosystem Services Approach

Final Case Studies Annex

October 2018

Annex 2. Project Case Studies

Contents

1 Introduction

As set out in the Draft Final Methodology Report, the project's objectives include investigating the implications of different landscape appraisal approaches through three case studies to assess whether and how current supplementary VfM guidance can be revised and incorporated into WebTAG. This Annex sets out the selection and purpose of the case studies, and then presents draft analysis and interpretation of results.

1.1 Selection and Purpose of Case Studies

The case studies set out in this Annex identify approaches to define value estimates that can usefully and practically be applied through available evidence. The case studies cover both the impacts of the schemes and potential mitigation measures and test:

- The ability to screen impacts for analysis (as per the current qualitative screening of the severity of landscape impacts);
- The ability to identify and measure impacts sufficiently robustly;
- Availability of economic value evidence to support monetary valuation with sufficient robustness, and
- Availability of context data to enable available value estimates to be adjusted to be used in different locations, landscape (or natural capital) types, and transport scheme types.

For any approach to be practical, the data involved (e.g. GIS data of the footprint of the Scheme, land cover data etc.) will need to be obtainable within the timescales/ resources in which transport appraisals are undertaken. There is, therefore, significant benefit from any automation of analysis. For example, a 'lookup' or GIS-based process can be useful to collate environmental data and monetary value evidence. This, in turn, requires linking units used in specific economic value evidence with the units used to measure environmental impacts of transport schemes. These links are discussed further in the revised methodology report (5th March 2018, e.g. Section 5.1).

The units to be considered include:

- Units used in EIA and other environmental analysis on transport scheme that could provide data relevant to project appraisal;
- Landscape units: of land cover (or habitat) types (e.g. hectares) and of the services/ benefits from land cover / habitat types as relevant to the Landscape category in WebTAG;
- Transport units: how the footprint (e.g. hectares) or length (e.g. km) of transport infrastructure is measured, and how adjacent areas of land (i.e. within a certain distance of the scheme) are identified, and
- Valuation units: how values are expressed (e.g. £/household/year).

Where different units are used, challenge is about whether adjustments can be made to combine them in analysis (e.g. how to relate households, hectares and km), and their availability as spatial data (e.g. in GIS). The availability and quality of data will determine the practicality of calculating impacts using spatial / GIS-based approaches and give a basis for applying standardised values.

Case studies test a range of analyses of landscape impacts, which also include the adjustment of time horizons and discount rates used in the calculations. The tests inform the selection of both the methods put forward in this study, and their future evolution. Case studies also support the understanding of incentives for the early consideration of landscape and other environmental impacts in scheme design, and how to appraise the effects of mitigation measures for schemes.

The choice of case studies was discussed at project inception. Suggestions by the Project Board were considered in more detail at the meeting on December 5th, 2017 leading to selection of the following:

- A14 Cambridge to Huntingdon improvement scheme (Section 2);
- Improving the A3 at Hindhead (Section 3);
- Great Western main line electrification: Reading to Didcot (Section 4).

Background documents to all three case studies were provided and have been used to form the basis of this analysis, see Table 1.1. The projects used had some data availability and consistency issues. These are highlighted in the descriptions of each case study. Analysis is based on the environmental statements and other documentation for the schemes, but documents showing the appraisal calculations (e.g. appraisal summary tables and application of the supplementary VfM Landscape Guidance) have not been available. This means there is a degree of uncertainty in the estimates produced. The analyses should not be regarded as complete, or as a re-appraisal of the schemes concerned.

Table 1.1 background documents provided

A14 Cambridge to Huntingdon	Environmental Statement: Chapters 0 to 21, Figures, Non-technical summary, and Appendix 10.07 Construction Environmental Management Plan: Sections 1 to 4 A14 Integrated Delivery Team, Environmental Management Plan A14 IDT Business Case
Improving the A3 at Hindhead	Environmental Statement: Vol 1, Vol 1A, Vol 2 Post Opening Project Evaluation PRESS RELEASE: Anniversary sees former site of A3 at Hindhead recognised as a wildlife haven
Great Western main line electrification: Reading to Didcot (GWRE)	Environmental Statement: • Volume 1A: General sections • Volume 1B: South Oxfordshire District Council • Volume 1B: Reading Borough Council • Volume 2: Appendices A-D, Reading Borough Council • Volume 2: Appendices A-D, South Oxfordshire District Council • Volume 3: South Oxfordshire District Council Figures

	• Volume 3: Reading Borough Council Figures NAO, Modernising the Great Western Railway Welsh Government, Great Western Main Line Electrification - Cardiff to Swansea, Outline Business Case House of Commons, Committee of Public Accounts, Modernising the Great Western Railway, Forty-fourth Report of Session 2016–17 Visual Amenity Review, Phase 1 Output Report, Appendix 1 to 8

1.2 Methodology

This section outlines the methodology used for the case studies which involves assessing:

- The area of land impacted;
- Analysis of the impacts on ecosystem services prioritised in the project methodology report, namely: landscape aesthetics, air quality, noise, recreation and carbon sequestration; and
- Sensitivity analysis.

1.2.1 Area of Land Impacted

The appraisal of landscape impacts in the supplementary VfM guidance is based on assumptions about the area of land impacted within a certain distance of the transport infrastructure. Guidance is given to consider impacts up to 500m from the infrastructure, but in reality there is variation in how values are affected by different types of infrastructure and in different circumstances such as the type of scheme, and the type of habitats (e.g. woodland and/or topography can mitigate visual and noise impacts compared to open habitats).

The VfM guidance assumes linearly declining value from full value to 0 between 0 and 500m from the scheme. The case studies test different assumptions about the distance over which impacts occur from the transport infrastructure. For example, 50% of the value of a service can be assumed to be lost for areas within 250 meters and 20% is lost for 250 to 500 meters away. Other assumptions about this distance of impact are tested through the case studies.

1.2.2 Landscape Aesthetics

The current WebTAG methodology for evaluating landscape impacts uses a qualitative assessment using a seven-point scale based on the scheme's fit with the landscape or landform, visual amenity, loss of character, degree of mitigation and effect on policies.

The environmental statements for the A3 and A14 schemes provide estimates of the number of properties that experience a negative or positive visual effect because of each scheme. This qualitative information is extremely valuable and can be monetised. However, care needs to be taken in this process does not to reveal potentially sensitive data on individual properties. Visual impact depends on lines of sight, and this is tested using GIS viewshed analysis in the GWRE case.

As discussed in the Methodology Report, values from Mourato el al. (2010) can be used to appraise the aesthetic or visual amenity impacts of transport schemes where they impact a property's 'view of nature'. Mourato et al. (2010) as part of the UKNEA calculated the marginal value to health and emotional wellbeing of having a view of nature compared to no view of nature at £350/person/year (for views enjoyed by residents). The range is from £161/person/year to £539/ person/year (all 2017 prices). The Mourato et al. values need to be used carefully in the context of transport schemes because it measures an "extreme" change (i.e. a view of nature from a property versus not having a view of nature). In the case of a new transport scheme going through a natural landscape, the nature view with / without the transport scheme can also be a large change. However, for transport infrastructure upgrades, and infrastructure going through an urban area, the change would be much smaller.

It is also worth mentioning that the authors underline that the associations between the wellbeing indicator and view of nature cannot be interpreted as causal effects. Furthermore, the monetary value is *tentatively* assigned to the QALYs associated with the environmental changes of interest. Therefore, these figures are indicative only and subject to many assumptions (described in the literature review) and should therefore be treated with caution. However, they are used here as they represent the best available evidence, and because they help test the calculation process.

We use the average (Median) value of £349.85/person/year to value the impacts on households with a large visual impact reported by the qualitative scheme assessments. In practice, this means that the number of properties with the greatest change (both positive and negative), multiply them by the average number of person per household, and calculate the Present Value. The value per person per year is assumed to be constant (i.e. there is no income elasticity assumed). In a formula it can be shown as:

$$PV = \sum_{t=0}^{n} \frac{349.85 * 2.3 * P_t^p}{(1+r_t)^t} - \sum_{t=0}^{n} \frac{349.85 * 2.3 * P_t^n}{(1+r_t)^t}$$

r_t the discount rate, declining over time as per HM Treasury Green Book requirement

$t = 1, \dots, n$ the time horizon, generally 60 or 100 years, reflecting Green Book guidance

P_t^p The number of properties positively affected in year t

P_t^n The number of properties negatively affected in year t

2.3 is the average household size in the UK (2011 census[22])

As the Environmental Statements provide some qualitative information regarding the severity of the visual impacts, we also tested applying different values from the range £161/person/year to £539/ person/year, giving larger visual impacts higher values and vice-versa. More details are provided in the A3 case study.

[22] https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/bulletins/populationandhouseholdestimatesfortheunitedkingdom/2011-03-21

1.2.3 Air quality

The current UK Government methodology (Defra, 2011) for appraisal of local air quality impacts due to infrastructure projects considers NO_2 and PM10 concentrations and numbers of properties affected (using GIS). This should consider the role of mitigation played by vegetation, taking account of how this can both reduce or worsen local concentrations of pollutants. This is only likely to provide a slight overall reduction at best, but nevertheless may be worth considering – especially when appraising mitigation options.

As outlined in the Methodology Report, detailed modelling of the role of vegetation in mitigating air pollution has recently been undertaken in the UK to include national pollution removal in ecosystem accounts (Jones et al, 2017).

This modelling by Jones et al (2017) has the potential to improve WebTAG's coverage the role of vegetation in air quality. A simple interpolation of the figures from Jones et al derives the average per hectare values for woodland and non-woodland habitats in urban and non-urban areas, as shown in Table 1.2. They show a very large range, illustrating the variability in the value of this ecosystem service in different locations. However, these figures are the result of comparing different versions of the modelling conducted by Jones et al (2017) so are only indicative values.

Table 1.2 Indicative Values for Air Quality Regulation by Vegetation Derived from Jones et al. (2017)

Asset values	Urban (£/ha)	non-urban (£/ha)
Woodland	**40,080**	**3,448**
Non-woodland	**69**	**235**

The A3 and the A14 case studies both provide an estimate of hectares of areas lost (or gained) by habitat type. Therefore, it is possible to estimate the present value of the air quality regulation by multiplying the areas of these habitats by the per ha values shown in Table 1.2.

1.2.4 Noise regulation by Vegetation

Noise from vehicles is already subject to standardised appraisal approaches in Government. The current methodology for appraisal of transport noise impacts in WebTAG should be carried out using the Calculation of Road Traffic Noise (DoT, 1988) and the Calculation of Railway Noise (DoT, 1995) as standard prediction methodologies. Defra's noise modelling tool uses dose-response functions for each impact pathway, for road, railway and aviation noise following the guidance on noise exposure (decibel reduction) from road (also includes rail and aviation) to estimate monetary values (Defra, 2014; Nellthorp et al, 2005). Monetary valuation of changes in noise is based on estimating the number of Disability-Adjusted Life Years (DALYs) lost (or gained) through each impact pathway, and monetisation with a value in 2014 prices of £60,000 per DALY.

In addition to quantifying and monetising the impacts of noise from the transport scheme itself, it is also possible to value the impacts of a change to noise mitigation due to changes in the extent of natural capital (trees) as a result of a scheme. The change to this ecosystem service is relevant to the Landscape category of WebTAG. The method from eftec (2017) specifically values this service. Alternatively, changes in properties' exposure to noise could also be valued using results of Day et al (2010).

However, the level of detail in the information provided for the case studies was not sufficient for the change in noise exposure of properties as a result of vegetation to be tested. For the A3 and the A14 case studies, information is available on how many properties will experience reduced or increased noise levels due to the scheme. However, this is assessed in aggregate for the scheme, and it was not possible to separate the effect of the transport scheme itself from the impact of changes to natural capital – both in terms of the removal of trees and any mitigation measures taken. Therefore, it is not possible to distinguish if changes in noise are due to changes in ecosystem services related to the Landscape appraisal category in WebTAG, or to the effects of a scheme (e.g. on traffic levels). Rather than value this service from natural capital separately, it is preferable to ensure that the influence of changes in natural capital are included in the overall assessment of the noise impacts of a scheme.

1.2.5 Recreation

WebTAG identifies several ways through which a transport scheme could impact recreation, including: (i) Direct loss of formal recreational areas and/or loss of amenity value of formal recreational areas; (ii) Severance of (public) rights of way and/or loss of amenity value of rights of way, and (iii) Direct loss of public open space/common land and/or loss of amenity value on open areas.

Identification of recreation sites affected are based on assumptions about distances from the scheme. A basic assumption in current appraisals is that sites are affected if they fall within a certain distance (e.g. 500 meters) from the scheme. The recreation value of these sites may be completely lost or partially reduced due to the scheme as per (i) to (iii) above. However, impacts may also arise over larger differences than 500 meters, which are investigated through the case studies.

Recreation values are largely site-specific and strongly influenced by factors such as the size of the surrounding population and local substitutes. Therefore, there cannot be a general recreation value (e.g. £ per ha) that applies uniformly. We propose to estimate the recreational values in England and Wales through the ORVal tool, which accounts for the factors that are found to influence values, and is a fairly practical source from which to obtain values. The tool has recognised limitations such as in being able to account for some site-specific characteristics. Despite this, use of ORVal remains to be the most practical option to estimate the recreation benefits of sites affected combined with distance assumptions to estimate losses or gains of recreation value (see 1.2.1).

It should be noted that the values used in these case studies were taken from ORVal in April 2018. The latest ORVal model (released June 2018) is updated in several respects, but has the same underlying approach. Therefore, the values used are accurate as a way of testing the approach of using ORVal for scheme appraisal, which is the purpose of the case studies.

1.2.6 Carbon sequestration

If a transport scheme results in permanent loss of a hectare of natural habitat, this will result in the loss of the carbon stored in that habitat and its ability to sequester carbon in future. This loss of carbon sequestration is particularly relevant with woodland areas and peat soils. When woodland habitat is removed, the stock of carbon stored in the woodland may be omitted (depending on the use of the timber), and the future sequestration by the woodland will be lost.

The stock of carbon in UK woodlands varies with woodland type and environmental conditions. However, the carbon impacts of woodland removal by transport schemes depend on what happens to the timber. This is not known for the case studies, so an average value for woodland carbon is used. eftec et al (2014) estimated that in 2012, UK woodlands held 213 $MtCO_2e$ across 2.78m hectares of woodland. This gives an average stock of 77tC per hectare, which at current carbon prices (the central non-traded price for 2017is £64 / tCO_2e) is approximately £5,000 per ha.

For loss of future sequestration, the ONS (2016) estimates of carbon sequestration across the UK woodland area can be used. Assuming a proportional approach, this figure tells us that a hectare of woodland in the UK on average sequesters 5 tCO_2e, which is stored and accumulates over time. We then recommend valuing the physical flow using the non-traded carbon value from BEIS guidance[23].

When hectares of woodland are gained as a part of a mitigation measure of the Scheme, these will sequester and store carbon provided they are managed as woodland over the long-term. The amount of sequestration in new woodland has a different quantity and time profile to existing woodland. Therefore, we recommend applying Woodland Carbon Code guidance on measuring the quantity of additional carbon sequestration over time. This measurement is dependent on commitments for long term management of the land as woodland habitat (Forestry Commission, 2018).

1.2.7 Sensitivity Analysis: discount rates and time horizon

The time horizon and the discount rates are fundamental aspects of the appraisal. In general, these parameters should be consistent with those used throughout WebTAG, but there can be instances where other assumptions are justified. Therefore, it is important to test different combinations and understand the empirical implications of such choices.

The current monetised landscape assessment is provided over the 60-year appraisal period. In the case studies we will test a 60-year and 100-year period. The longer time horizon is chosen in order to more fully consider the potential long-term effects of environmental changes on future generations in appraisal.

Regarding the discount rates, we are testing two options: one is the standard Social Time Preference Rate recommended by the Green Book, the second is the discount rate

[23] https://www.gov.uk/government/collections/carbon-valuation--2

recommend by the latest version of the Green book (in prep) for health impacts, see Table 1.3. As ecosystem services provided by the landscape have a large impact on human health, the health rate may be the most suitable one.

Hence, we will test four different scenarios:

- PV60 STPR, with STPR discount rates and appraisal period of 60 years
- PV100 STPR, with STPR discount rates and appraisal period of 100 years
- PV60 Health, with "Health" discount rates and appraisal period of 60 years
- PV100 Health, with "Health" discount rates and appraisal period of 100years

Table 1.3 Green Book discount rates schedule

Year	0 – 30	31 – 75	76 - 125	126-200	201-300	301+
STPR (standard)	3.50%	3.00%	2.50%	2.00%	1.50%	1.00%
STPR (reduced rate where pure STP = 0)	3.00%	2.57%	2.14%	1.71%	1.29%	0.86%
Health	1.50%	1.29%	1.07%	0.86%	0.64%	0.43%
Health (reduced rate where pure STP = 0)	1.00%	0.86%	0.71%	0.57%	0.43%	0.29%

Source: HM Treasury Green Book (2018).

1.2.8 Sensitivity testing of landscape "footprint"

The Supplementary Guidance on Landscape Step 4 is to determine the landscape "footprint", i.e. the size of the area affected by the landscape changes (DfT 2016). As a guideline, DfT recommends assuming, for simplicity, that for each Km of Scheme, 50 hectares are lost (25 on each side). In other words, 250 meters of landscape on each side of the scheme are assumed to be "lost".

Three possible scenarios can be tested:

- MAX scenario, 100% of the landscape value is lost for 500 meters on each side of the Scheme;
- INT scenario, as per current recommendation, 100% of impact from 250 meters on each side[24]; and
- MIN scenario, 100% of the value is lost for the first 100 meters, and 50% is lost for the following 100 meters.

As case studies don't have data on this, hypothetical values are tested. The present value of benefits per hectare for different land types for the current (adjusted) supplementary VfM

[24] This is equivalent to assuming a linear decline in value over the distance assessed. The assumption used can be adjusted to take into account different lad types within 500m of the scheme.

guidance and alternative values are taken from Table A3.1 in the Methodology Report. To illustrate this calculation, the Land Type "rural forested land" is used.

This basic exercise shows that the MIN scenario provide figures that are 30% of the MAX scenario, regardless of the habitat type or the values used (alternatively, the MAX scenario shows value losses 3.3 times larger than the MIN scenario). Therefore, sensitivity analysis shows the definition of landscape footprint is an important factor which needs to be considered carefully.

Furthermore, the MAX scenario is potentially an underestimate – some aspects of landscape impacts (e.g. visual impacts) could extend further than the 500 m distance. Assumptions about this distance over which a transport scheme has impacts is examined further in Section 4.

Table 1.4 Sensitivity testing of distance bands

Rural forested land - Present value per ha (2017 £m)					
Values from Table A3.1 of methodology Report:				In WebTAG (adjusted)	Alternative values of ES
Assumptions		ha per km	weighting	£1.0 m	£0.45 m
MAX	100% of impact over 500m either side	50	100%	£100.0 m	£45.0 m
INT	100% of impact for 250m	25	100%	£50.0 m	£22.5 m
MIN	100% of impact for 100m, 50% for further 100m	10	100%	£20.0 m	£9.0 m
		10	50%	£10.0 m	£4.5 m
		Total		£30.0 m	£13.5 m

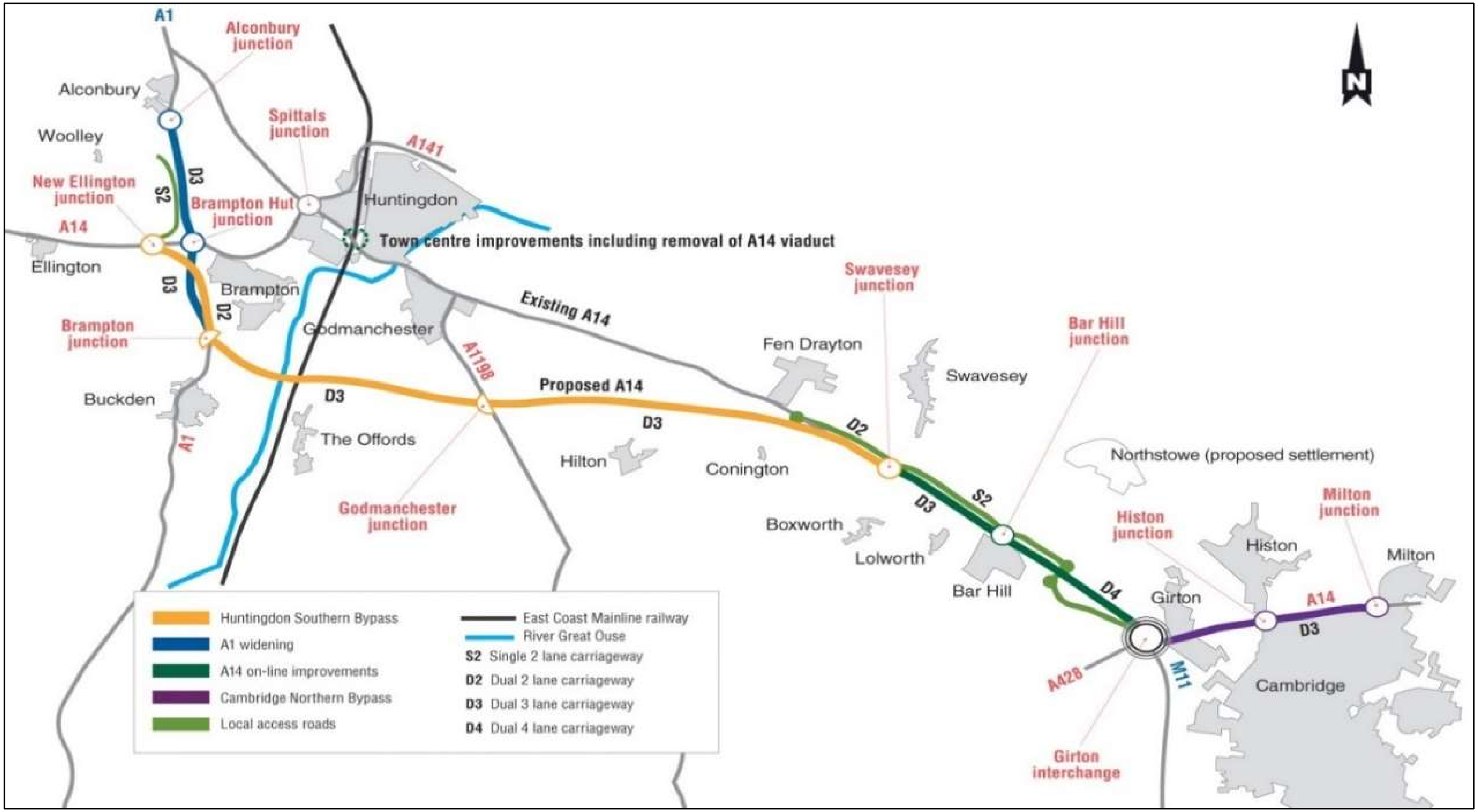
2 A14 Cambridge to Huntingdon improvement scheme

The A14 trunk road is an east-west route which links the Midlands with East Anglia. It begins near Rugby, where it connects with the M1 and M6 motorways, and continues east for approximately 209 km (130 miles) to the port town of Felixstowe. It is one of the UK's strategic routes and part of the Trans-European Transport Network designated by the European Union.

The Scheme involved widening existing roads, construction of new bypasses, link roads and local access roads, as well as the demolition of a viaduct, as shown in Figure 2.11. During the construction, the Scheme required 6 borrow pits, which are local areas excavated to provide material to use in construction, such as sand, gravel and clay. The scheme also included numerous environmental mitigation features including flood storage areas, earth mounds, landscaping, nature conservation mitigation areas and noise screens. These features have all been considered as part of the environmental impact assessment, along with construction facilities such as site compounds, soil storage areas and temporary accommodation for construction workers.

The scheme aims to address the insufficient traffic capacity on the existing trunk road between Cambridge and Huntingdon. The improvement aims to relieve local traffic congestion, improve connectivity and safety in the Cambridge area, as well as creating a positive environmental legacy. Construction on the improvement scheme began in 2016, with expectation that it will be open to traffic by 2020.

Figure 2.1 A14 improvement scheme schematic (Source: A14 IDT Business Case, 2016)



2.1 Landscape aesthetics

Table 2.1 compares the valuation evidence proposed for this impact category with the relevant information on the good, the change and the affected population from the case study documentation. The differences shown in the Table 2.3 result in the significant uncertainty in using the evidence from Mourato et al (2010) for this purpose.

Table 2.1. A14 case study – Landscape aesthetics value transfer

	Case study	Valuation evidence
The good	Visual effects on properties	Wellbeing from a 'view of nature' from your house (Mourato et al, 2010)
The change	Large and very large visual adverse or beneficial visual effects	No view of nature against any view.
The beneficiaries	Property occupants affected by the A14 improvement Scheme	Nearly 2,000 online survey respondents representing UK residents aged 16 and above. Sampling was by pre-recruited panel meeting quota based on Annual Population Survey data

Table 2.2 below presents how the visual effects vary over time. Only "large" and "very large" effects are considered. The analysis attributes the same marginal value to the two categories. The values from Mourato et al are more relevant to the "very large" effects identified in this case study, but their use still has significant uncertainty. A complication with housing numbers can arise if transport infrastructure schemes are part of wider land use development proposals that also include housebuilding. In this can the housing stock affected within the schemes viewshed could change if the scheme is constructed.

Table 2.1 A14 case study – Summary of visual effects

Visual receptor/timescale	Number of properties			
	Adverse		Beneficial	
	Very large	Large	Large	Very large
Residential properties: 2016-2019, construction	117	215	0	0
Residential properties: 2020-2034, from winter year 1	19	70	86	0
Residential properties: 2035-onwards, from summer year 15	0	29	96	0

The visual impacts of scheme construction reduce over time as mitigation measures take effect (e.g. trees grow) combined with the positive impacts of removing the flyover. Most of the negative effects are limited to the construction period and the immediate aftermath. Conversely, in the long run positive visual effects are expected. Unsurprisingly given this asymmetric distribution of impacts over time, the total present value changes dramatically depending on the discount rates used, highlighting the importance of appraising the distribution of positive and negative outcomes over time.

As shown by Table 2.23 below, the higher the discount rate, the lower the present value of a given impact over a given time period. Aggregating future impacts and values over different time periods also makes a difference to present values, as expected. This occurs especially with low discount rates, as the present value increases 4 times by adding 40 years to the time horizon, reaching over £1.1 million. For brevity, only the present value over 100-years is reported.

The value of visual impacts identified is likely to be material in relation to the cost of measures to mitigate them. However, it is relatively low compared to the overall costs and benefits of the Scheme. As discussed in Section 1.2.2, we note that these figures are indicative only and subject to many assumptions and should therefore be treated with great caution.

Table 2.2 A14 case study - Summary of monetised visual impacts

Output Table - Visual Impacts (baseline 2016)							
Discount rates as per Section 1.2.7		STPR			Health		
Visual receptor		Residential	Commercial	Total	Residential	Commercial	Total
PV60	**Very large adverse**	-£0.52 m	£. m	-£0.52 m	-£0.56 m	£. m	-£0.56 m
	Large adverse	-£1.55 m	£. m	-£1.56 m	-£1.98 m	£. m	-£1.99 m
	Large beneficial	£1.74 m	£. m	£1.74 m	£2.83 m	£. m	£2.83 m
	Very large beneficial	£. m	£. m	£. m	£. m	£. m	£. m
	Total PV60	-£0.32 m	£. m	-£0.33 m	£0.28 m	£. m	£0.28 m
PV100	**Total PV100**	-£0.06 m	£. m	-£0.06 m	£1.15 m	£. m	£1.15 m

2.2 Air quality

Table 2.4 compares the valuation evidence proposed for this impact category with the relevant information on the good, the change and the affected population from the case study documentation. Given the comparability of these factors, there is strong evidence for using Jones et al (2017) values.

Table 2.45 shows the total hectares lost and gained as a result of the A14 scheme. The calculation ignores temporary gains and losses and only considers permanent effects. This may lead to an underestimation of the effect as there are important temporary land losses during the construction process.

Table 2.3 A14 case study – Air quality regulation by vegetation valuation evidence

	Case study	Valuation evidence
The good	Air quality regulation from vegetation	Indicative values of air pollutant removal by vegetation derived from modelling by Jones et al (2017)
The change	Change in health impacts of air pollution following change in pollutant removal due to habitat loss or gain	Avoided health impacts due to pollution removal (respiratory hospital admissions, cardiovascular hospital admissions, loss of life years, deaths)
The beneficiaries	Residents and visitors around the scheme	Applies across the UK population

Table 2.4 A14 case study – habitat loss and gain

	Total Area Loss (ha)	Total Area Gain (ha)
Woodland	25	91
Non-woodland	1000	346

The habitat areas are then valued using the estimates for air quality regulation by vegetation by Jones et al (2017) as discussed in Section Air quality1.2.3. To follow a conservative approach, the (lower) non-urban values from Jones et al (2017) are used here.

The habitat gains are achieved with different methods, for instance creating new habitats along the highways estate and in the restored borrow pit areas. It could be argued that these new habitats will not significantly affect the air quality until the vegetation is fully grown. Therefore, as illustrative assumptions, a 10-year lag has been used for woodland gains and a 1-year lag for non-woodland gains. Scheme-, habitat- and ecosystem-service specific assumptions should be made for lags in the impacts of mitigation in individual transport scheme appraisals.

Table 2.5 A14 case study - Summary of monetised air quality regulation[25]

Output Table -Total present value (baseline 2018)							
Discount rates as per Section 1.2.7		STPR			Health		
		AQ loss	AQ gain	Net	AQ loss	AQ gain	Net
PV60	Woodland	-£2.38 m	£5.9 m	£3.53 m	-£3.62 m	£10.18 m	£6.55 m
	Non-woodland	-£6.46 m	£0.01 m	-£6.45 m	-£9.84 m	£3.32 m	-£6.52 m
	Total	-£8.83 m	£5.91 m	**-£2.92 m**	-£13.46 m	£13.5 m	**£0.03 m**
PV100	Woodland	-£2.8 m	£7.44 m	£4.64 m	-£5.02 m	£15.22 m	£10.2 m
	Non-woodland	-£7.61 m	£2.55 m	-£5.06 m	-£13.63 m	£4.63 m	-£9. m
	Total	-£10.42 m	£10. m	**-£0.42 m**	-£18.64 m	£19.85 m	**£1.21 m**

[25] Negative values are highlighted in red, positive in green

Depending on the discount rates and the time horizon used, the net result ranges from a loss of £2.9 million to a benefit of £1.2 million. This difference is influenced by the lag used, as benefits start occurring after the lag period, therefore increasing the time horizon leads to a higher net present value. A similar effect is obtained by reducing the discount rates which means more weight is given to distant benefits resulting in a higher present value.

2.3 Recreation

Table 2.7 compares the valuation evidence proposed for this impact category with the relevant information on the good, the change and the affected population from the case study documentation. Although the good and the beneficiaries compare well, the change of the case study is smaller than the change valued by ORVal: ORVal gives the loss of welfare if access to the site was no longer available, whilst in the case study, there may be only a partial loss of the quality of a site for recreation.

Table 2.6 A14 case study – Recreation valuation evidence

	Case study	Valuation evidence
The good	Recreational value of accessible green space areas and footpaths	Recreational value of accessible green space areas and footpaths from ORVal
The change	Loss of recreational welfare due to change in amount or quality of accessible area/ footpaths	Welfare values for an existing site are estimated by calculating how much individuals' welfare would fall if they were no longer able to access that site, or its area or land cover changed. Cannot measure impact of other changes in site quality on individuals' welfare.
The beneficiaries	Users of accessible green space and footpaths affected by the scheme	Adult residents of England who use accessible green space and footpaths.

The Scheme involved: widening existing roads, construction of new bypasses, link roads and local access roads, as well as the demolition of a viaduct. Therefore, it caused a loss in recreation values mainly due to direct loss of public open space/common land and loss of amenity value on open areas.

As discussed in the methodology report, the ORVal tool can be used to identify the affected sites that may have been affected. As a case study, ORVal was used to identify the sites that fall within 500 meters of the Scheme enlargements in Brampton.

Although these values are not completely lost, it is reasonable to assume that the Scheme would lead to a decrease. In the context of appraising a transport scheme, ORVal will provide estimated recreational values for sites potentially impacted prior to a scheme going ahead.

Table 2.7 provides a summary of the present value calculation using different discount rates and time horizons. The sum of welfare values for the affected footpaths and accessible areas ranges from about £12 million to £25 million. The range is generated by the discount rates and the time horizons, as the annual benefit value is assumed to be constant. If the impact of the scheme was some marginal change in these values, then this would be expected to be of an order of £ millions. Further research is needed to establish the size of this marginal impact. An illustrative range of impacts, based on the study team's previous experience of recreation appraisal, is that the loss could be between 10% and 50% of the total values, thus between £1.2 and £12.4 million depending on the scenario. This scale of impact is probably not material to the overall costs and benefits of the scheme. However, it could be very significant in relation to mitigation decisions for the scheme, and to the other environmental / landscape benefits appraised.

Table 2.7 A14 case study - Brampton sites welfare values

Brampton sites -welfare values					
		PV60 STPR	PV60 Health	PV100 STPR	PV100 Health
Footpaths	Welfare values	£3.45 m	£5.26 m	£4.07 m	£7.28 m
	AB	£1.22 m	£1.86 m	£1.44 m	£2.57 m
	C1	£1.13 m	£1.73 m	£1.34 m	£2.39 m
	C2	£.61 m	£.94 m	£.72 m	£1.3 m
	DE	£.48 m	£.74 m	£.57 m	£1.02 m
Areas	Welfare values	£8.32 m	£12.68 m	£9.81 m	£17.56 m
	AB	£2.93 m	£4.47 m	£3.46 m	£6.19 m
	C1	£2.72 m	£4.15 m	£3.21 m	£5.75 m
	C2	£1.48 m	£2.26 m	£1.75 m	£3.12 m
	DE	£1.18 m	£1.8 m	£1.4 m	£2.5 m
Total		£11.77 m	£17.94 m	£13.88 m	£24.85 m
Potential impacts					
10% of the total		-£1.18 m	-£1.79 m	-£1.39 m	-£2.48 m
50% of the total		-£5.89 m	-£8.97 m	-£6.94 m	-£12.42 m

The welfare values are decomposed by socio-economic status (i.e. A, B, C1, C2, D, E). See Section 2.6.2 of the Method Report Annex for more details

2.4 Carbon

Table 2.9 compares the valuation evidence proposed for this impact category with the relevant information on the good, the change and the affected population from the case study documentation. Given the comparability of these factors, there is a strong basis for using this evidence.

Table 2.8 A14 case study – Carbon sequestration valuation evidence

	Case study	Valuation evidence
The good	Carbon sequestration from woodland	Carbon sequestration & non-traded carbon value from BEIS guidance
The change	Change in volume of carbon sequestered and stored, based on hectares of woodland loss and gain	Non-traded carbon price based on estimates of the abatement costs that will need to be incurred to meet specific emissions reduction targets
The beneficiaries	World population	World population

As per section 2.2, 25 hectares of woodland are permanently lost and 91 are permanently gained. A summary of the valuation is given in Table 2.910. Due to the time lags involved, lower discount rates mean the value of carbon storage gains increase relative to the value of carbon sequestration loss. Therefore, not surprisingly the net present value increases almost four times from nearly £1 million, to £3.8 million, depending on the assumptions used.

Table 2.9 A14 case study – Monetary value of carbon sequestration

Output table			
Discount rates as per Section 1.2.7		STPR	Health
PV60	CS Loss	-£0.51 m	-£0.91 m
	CS Gain	£1.46 m	£2.87 m
	Net	£0.96 m	£1.96 m
PV100	CS Loss	-£0.7 m	-£1.62 m
	CS Gain	£2.16 m	£5.42 m
	Net	£1.46 m	£3.8 m

2.5 Following the "Supplementary Guidance on Landscape"

As a comparison, it is useful to compare the above results with the indicatively-monetised impacts using the Supplementary Guidance on Landscape (DfT, 2016). The guidance identifies the value of the bundle of ecosystem services provided by each land type as summarised in Box 2.3 of that guidance.

For each land type impacted, Table 2.11 reports the results of using the value estimates in terms of £ per hectare per year to calculate the present value of impacts under the four-time horizon and discount rate scenarios. This approach shows a net gain due to the Scheme. The result is driven mainly by the creation of 91 hectares of woodland as part of the mitigation measure.

Table 2.10 A14 case study – "bundle" approach

Land Impacted	ha	Land Type	PV60 STPR	PV100 STPR	PV60 Health	PV100 Health
Woodland	- 24	Urban Fringe (forested land)	-£2.67 m	-£3.16 m	-£4.12 m	-£5.74 m
Semi-improved grassland	- 77	Agricultural Land (extensive)	-£9.98 m	-£11.84 m	-£15.41 m	-£21.49 m
Arable	- 894	Agricultural Land (intensive)	-£3.78 m	-£4.48 m	-£5.84 m	-£8.14 m
	- 995	Total loss	-£16.43 m	-£19.48 m	-£25.36 m	-£35.36 m
Woodland	91	Urban Fringe (forested land)	£10.11 m	£11.99 m	£15.61 m	£21.77 m
Semi-improved grassland	63	Agricultural Land (extensive)	£8.17 m	£9.68 m	£12.61 m	£17.58 m
Arable	227	Agricultural Land (intensive)	£.96 m	£1.14 m	£1.48 m	£2.07 m
	381	Total gain	£19.24 m	£22.81 m	£29.7 m	£41.41 m
	-1,228	Net footprint only	£2.81 m	£3.33 m	£4.34 m	£6.05 m
Buffer - Arable	- 945	Agricultural Land (intensive)	-£3.99 m	-£4.74 m	-£6.17 m	-£8.6 m
	-2,173	Net footprint + buffer	-£1.18 m	-£1.4 m	-£1.83 m	-£2.55 m

Note: land type categories from supplementary guidance. No lag is assumed in the delivery of benefits from the habitat gain.

The estimated net present value of the impact of the footprint of the scheme ranges from £2.8 million under "PV60 STPR" and £6 million under "PV100 Health". These positive values result from the net gain of 66 ha of forested land outweighing the net loss of 654 ha of intensive agricultural land.

However, the Supplementary Guidance on Landscape recommends considering 25 hectares on either side of each km of the scheme as "lost". This approach cannot be applied in detail in this case study due to lack of data, but its consequences can be estimated.

Using GIS resources and CEH's Land Cover Map 2015 (1km resolution[26]) we found that roughly 85% of the 25ha of land adjacent to the new scheme route is classified as "Arable and Horticulture". We therefore assume that all this buffer zone is the land type "intensive agricultural land". This land type has the lowest per ha value for landscape ecosystem services in the supplementary guidance. Under the supplementary landscape guidance, each ha of intensive agricultural land is given a present value of £0.009m under PV100 Health. Each 25 ha of land would have a PV of £0.23m, which on both sides of a scheme would result in £0.46m per km.

The new A14 is approximately 18.9 Km long from our GIS approximation, giving a PV of £-8.6 million to be added to the impacts of the scheme under PV100 Health, or £-4 million under PV60 STPR. Other types of land have higher values (by one or more orders of magnitudes), and therefore the influence of assumptions to include adjacent land in the impacts considered is clearly significant. As a result, the Scheme results in a net loss instead of a net gain, with a present value ranging from £-1.2 to £-2.5 million. Taking these values into account gives the

[26] This data source is freely available: https://catalogue.ceh.ac.uk/documents/505d1e0c-ab60-4a60-b448-68c5bbae403e so was used to inform this case study. In transport project appraisals vector Land Cover Map data can be utilised, providing greater accuracy on habitat types.

'Net footprint + buffer' result in Table 2.11, which shows a significant negative value to the appraisal.

However, including these negative impacts would also suggest that benefits should be included where the existing road route is being removed. The net impact from the scheme is an increase in length of road, so if the negative and positive impacts are to similar land types the net impact would be an increase in the value of the scheme's negative impacts. However, given the wide range of values per ha of different land types, this conclusion could easily change if the benefits are to land types with higher values per ha, and the losses are for land types with lower values per ha.

The results of the appraisals tested on the A14 are shown in Table 2.12.

Table 2.12. A14 Appraisal Comparisons.

A14				
(£ m)	PV60 STPR	PV100 STPR	PV60 Health	PV100 Health
Aesthetics	-0.3	-0.1	0.3	1.2
Air Quality	-2.9	-0.4	0	1.2
Recreation	The change due to the scheme is not estimated, but potentially in the order of magnitude of £millions			
Carbon	1	1.5	2	3.8
Total	**-2.2**	**1**	**2.3**	**6.1**
Supplementary Guidance (partial)	2.8	3.3	4.3	6.1
Supplementary Guidance (full)	-1.2	-1.4	-1.8	-2.5

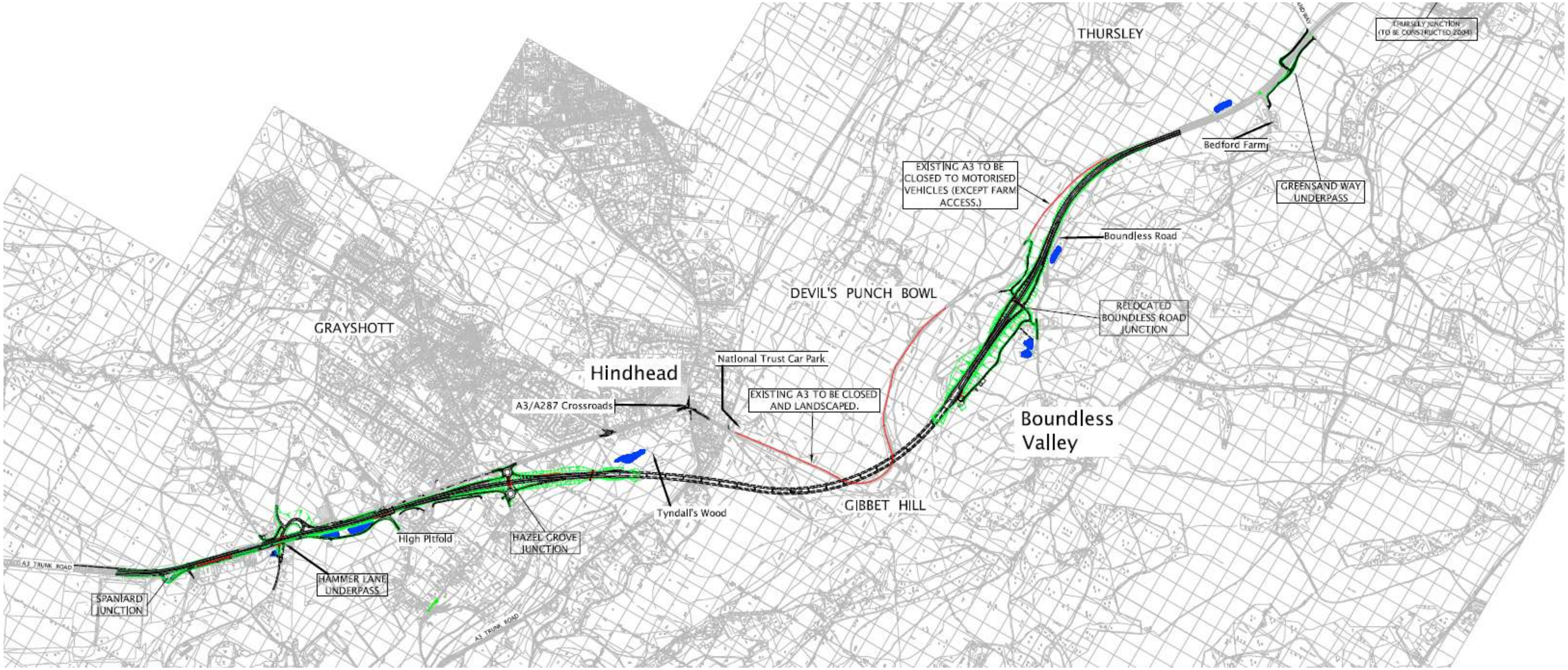
3 Improving the A3 at Hindhead

The A3 provides a link between London and Portsmouth. The Highways Agency proposed an improvement of the section of the A3 at Hindhead (Surrey) to a dual carriage way between Hammer Lane and Boundless Road. This section of the road was the only part that had not been upgraded to a dual carriageway. The infrastructure project involved the development of a 6.5km dual carriageway, including a 1.9km twin bored tunnels below Devil's Punch Bowl and Hindhead Common. The schematics of the Scheme are shown in Figure 3.11.

Additional features of the proposed improvement are eight bridges, the development of underpasses crossing the A3 from north to south, and footpaths for pedestrians.

In addition to completing the update of the A3 to a dual carriageway, the scheme also aimed to alleviate traffic congestion at the signal controlled crossroad and restore the historic landscape of Hindhead Common and the Devil's Punch Bowl, a site of special scientific interest (SSSI) and special protection area (SPA). Construction began in 2007, with the new A3 opening to traffic in July 2011.

Figure 3.1 A3 at Hindhead improvement scheme schematic (Source: A3 Environmental Statement Vol. 1A)



3.1 Landscape aesthetics

Table 3.1 compares the valuation evidence proposed for this impact category with the relevant information on the good, the change and the affected population from the case study documentation. It shows differences between the case study and valuation evidence for both the good and the change, which is why there is significant uncertainty in using the evidence from Mourato et al. (2010).

Table 3.1 A3 case study - Landscape aesthetics value transfer

	Case study	Valuation evidence
The good	Visual effects on properties	Wellbeing from a 'view of nature' from your house (Mourato et al, 2010)
The change	Large and very large visual adverse or beneficial effects	No view against any view.
The beneficiaries	Property occupants affected by the A3 improvement Scheme	Nearly 2,000 online survey respondents representing UK residents aged 16 and above. Sampling was by pre-recruited panel meeting quota based on Annual Population Survey data

Table 3.22 below shows how the visual effects of the scheme vary over time. Only properties with "extreme" visual effects are considered, which refer to the following categories: severe adverse, substantial adverse, moderate adverse, moderate beneficial, and substantial beneficial. The analysis used values from Mourato et al. (2010) as follows:

- The minimum value £161/person/year for "moderate" effects
- The midpoint value £350/person/year for "substantial" effects
- The maximum value £539/person/year for "severe" effects

Table 3.2 A3 case study - Summary of visual effects

Visual receptor/timescale	Number of residential properties				
	Sev. adverse	Sub. adverse	Moderate adverse	Moderate beneficial	Sub. beneficial
Residential properties: 2005-2009 construction	14	28	33	0	0
Residential properties: 2009-2023 winter year 1	3	15	35	28	0
Residential properties: 2024-2065 summer year 15	0	2	21	28	0

As shown by Table 3.2, the discount rates or the time period do not significantly alter the result: the present value ranges from a loss of £364k to £404k. This is due to the fact that positive and negative effects from year 15 onwards are relatively symmetrical therefore they tend to balance each other.

It should be noted that these figures are indicative only, and subject to many assumptions as described in Section 1.2.2 and should therefore be treated with caution.

Table 3.3 A3 case study - summary of monetized visual impacts

Output Table - Visual Impacts								
Discount rates		STPR			Health			
Visual receptor		Residential	Commercial	Total	Residential	Commercial	Total
PV60	**Sev. adverse**	-£.1 m	£. m	-£.1 m	-£.12 m	£. m	-£.12 m
	Sub. adverse	-£.23 m	£. m	-£.23 m	-£.28 m	£. m	-£.28 m
	Moderate adverse	-£.28 m	-£.01 m	-£.3 m	-£.41 m	-£.02 m	-£.43 m
	Moderate beneficial	£.25 m	£.02 m	£.26 m	£.39 m	£.03 m	£.42 m
	Sub. beneficial	£. m	£. m	£. m	£. m	£. m	£. m
	Total PV60	-£.38 m	£. m	-£.37 m	-£.41 m	£.01 m	-£.4 m
PV100	**Total PV100**	-£.37 m	£.01 m	-£.36 m	-£.4 m	£.02 m	-£.38 m

3.2 Air quality

Table 3.4 compares the valuation evidence proposed for this impact category with the relevant information on the good, the change and the affected population from the case study documentation. It shows overlaps between the case study and valuation evidence for the good, change and beneficiaries. Therefore, there is strong evidence for using Jones et al values.

Table 3.4 A3 case study – Air quality valuation evidence

	Case study	Valuation evidence
The good	Air quality regulation from vegetation	Indicative values of air pollutant removal by vegetation derived from modelling by Jones et al (2017)
The change	Change in health impacts of air pollution following change in pollutant removal due to habitat loss and gain	Avoided health benefits due to pollution removal (respiratory hospital admissions, cardiovascular hospital admissions, loss of life years, deaths)
The beneficiaries	Residents and visitors around the scheme	Applies across the UK population

Table 3.55 below shows the total hectares lost and gained as a result of the scheme. The calculation ignores temporary gains and losses and only considers permanent effects. This may lead to an underestimation of the effect as there can be important temporary land losses during the construction process. Our calculation focusses on the area of habitat lost due to scheme construction.

Table 3.5 A3 case study – Land loss

	Total Area Loss (ha)
Agriculture	7
Woodland	25
Non-woodland	25

The habitat areas are then valued using indicative values for air quality regulation by vegetation from Jones et al (2017) as discussed in Section 1.2.3. We maintained a conservative approach, and applied the (lower) non-urban values.

The present values range from £2.6 million to £5.4 million. Lower discount rates and a longer time horizon lead to a greater air quality regulation value loss. The calculation illustrates that when the effect has one direction (i.e. only negative in this case), and the loss is constant over time, the scenario "PV100 Health" leads to twice the present value of the scenario "PV60 STPR".

Table 3.6 A3 case study - Summary of monetised air quality regulation

Output Table - Total present value (£)					
Discount rates as per Section 1.2.7		STPR		Health	
		AQ loss	AQ gain	AQ loss	AQ gain
PV60	Agriculture	-£0.04 m	£. m	-£0.07 m	£. m
	Woodland	-£2.36 m	£. m	-£3.59 m	£. m
	Non-woodland	-£0.16 m	£. m	-£0.25 m	£. m
	Total	-£2.57 m	£. m	-£3.91 m	£. m
PV100	Agriculture	-£0.05 m	£. m	-£0.09 m	£. m
	Woodland	-£2.78 m	£. m	-£4.98 m	£. m
	Non-woodland	-£0.19 m	£. m	-£0.34 m	£. m
	Total	-£3.03 m	£. m	-£5.42 m	£. m

3.3 Recreation

Table 3.7 compares the valuation evidence proposed for this impact category with the relevant information on the good, the change and the affected population from the case study documentation. Although the good and the beneficiaries compare well, the change in the case study is different to the one valued by ORVal. In this case study, there is an improvement in the quality of parts of the site for recreation due to improved landscape visual quality as a result of removing parts of the old A3 road.

The main outcome of the Scheme is a new 1.9km twin bored tunnel below Devil's Punch Bowl and Hindhead Common. Therefore, the project restored the historic landscape of Hindhead Common and the Devil's Punch Bowl, a site of special scientific interest (SSSI) and special protection area (SPA).

For this case study, the ORVal tool was used to identify recreational values for the sites that border the new tunnel approaches, as per Figure 3.2 below.

Table 3.7 A3 case study – Air quality valuation evidence

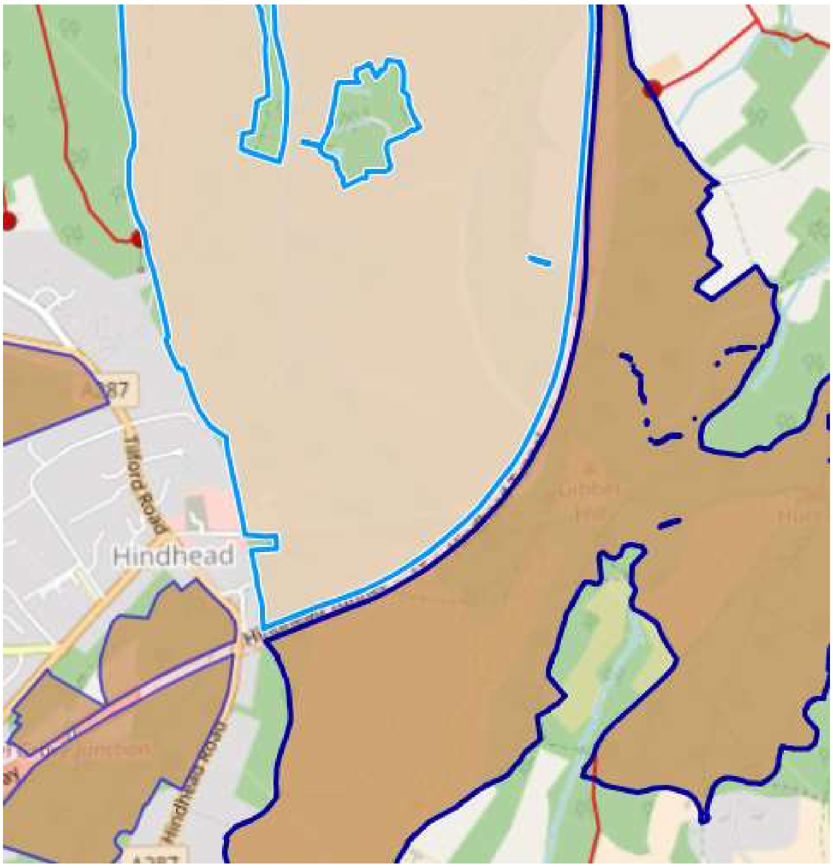
	Case study	Valuation evidence
The good	Recreational value of accessible green space areas and footpaths	Recreational value of accessible green space areas and footpaths from ORVal
The change	Gain of recreational welfare due to change in amount or quality of accessible area/ footpaths	Welfare values for an existing site are estimated by calculating how much each individual's welfare would fall if they were no longer able to access that site, or its area or land cover changed. Cannot measure impact of other changes in site quality.
The beneficiaries	Users of accessible green space and footpaths.	Adult residents of England who use accessible green space and footpaths.

The present value of the two areas (outlined in light and dark blue in Figure 3.22) is summarised in Table 3.88 using different discount rates and time horizons. The sum of the present value of recreational welfare from ORVal ranges from £7.3 to £15.4 million.

The Environmental Statement reports that the number of visits to Hindhead Common and the Devil's punchbowl increased substantially after the implementation of the scheme. The size of this increase is not known. Similarly, in other appraisal circumstances, the expected negative impacts of a transport scheme on visitor numbers to a site would be unlikely to be quantifiable.

In ex-ante appraisal, the impacts of positive changes in recreation value from this kind of scheme could be predicted (based on expert judgement of further research evidence) with reference to the values in ORVal. Where a scheme marginally improves or reduces the recreational value of a site, impacts as estimated as between 10% and 50% of total values (see Section 2.3). However, this is a not a satisfactory method, as there are circumstances where impacts could be significantly larger. Hindead Common is one such site, as its recreational attractiveness includes features including open habitats (e.g. heathland) and a high-quality landscape that has been significantly enhanced by the A3 scheme. Therefore, increases in recreational value could be more than 50%.

Figure 3.2 A3 case study – Devil's Punch Bowl on ORVal



Applying the 10%-50% assumptions to the ORVal data gives an estimated welfare value increase of between £0.7 and £7.7 million, depending on the scenario. These values are highly uncertain, but illustrate potential impacts of an order of £ millions, which are therefore material to the design of mitigation measures associated with the scheme.

Table 3.8 A3 case study – Devil's Punch Bowl Welfare Values

Devil's Punch Bowl - Welfare Values					
Discount rates as per Section 1.2.7		PV60 STPR	PV60 Health	PV100 STPR	PV100 Health
Socio-economic breakdown	Welfare value	£7.32 m	£11.15 m	£8.63 m	£15.44 m
	AB	£3.18 m	£4.84 m	£3.74 m	£6.7 m
	C1	£2.29 m	£3.48 m	£2.69 m	£4.82 m
	C2	£1.14 m	£1.73 m	£1.34 m	£2.4 m
	DE	£0.72 m	£1.09 m	£0.84 m	£1.51 m
10% of welfare value		£0.73 m	£1.11 m	£0.86 m	£1.54 m
50% of welfare value		£3.66 m	£5.57 m	£4.31 m	£7.72 m

The welfare values are decomposed by socio-economic status (i.e. A, B, C1, C2, D, E). See Table 2.8 for details.

3.4 Carbon

Table 3.9 compares the valuation evidence proposed for this impact category with the relevant information on the good, the change and the affected population from the case study documentation. Given the good comparability across the good, change and beneficiaries, there is a strong basis for using this evidence.

Table 3.9 A3 case study – Carbon sequestration valuation evidence

	Case study	Valuation evidence
The good	Carbon sequestration from woodland	Carbon sequestration & non-traded carbon value from BEIS guidance
The change	Change in volume of carbon sequestered and stored, based on hectares of woodland loss and gain	Non-traded carbon price based on estimates of the abatement costs that will need to be incurred in order to meet specific emissions reduction targets
The beneficiaries	World population	World population

As described in Section 3.2, 25 hectares of woodland are permanently lost. A summary of the valuation of this loss is given in Table 3.10. The net present value ranges from a loss of £425k to £1.4 million, depending on the assumptions used. It is worth noting that the scenario "PV100 Health" leads to more than three times the present value of the scenario "PV60 STPR" due to increasing carbon prices over time.

Table 3.10 A3 case study – monetized carbon sequestration

Discount rates as per 1.2.71.2.7		STPR	Health
PV60	CS Loss	-£0.425 m	-£0.77 m
	CS Gain	£0 m	£0 m
PV100	CS Loss	-£0.622 m	-£1.41 m
	CS Gain	£0 m	£0 m

3.5 Following the "Supplementary Guidance on Landscape"

Table 3.1111 summarises the monetised value of the land loss using the current Supplementary VfM Guidance on Landscape Values (DfT 2016). The permanent land loss data is found in the Environmental Statement and corresponds to the column "Land impacted". The land type is matched to categorisation used in the main Methodology Report. Although these are designated areas within the scheme appraisal boundary, these were not analysed in detail, as they are assumed to be dealt with in the 'biodiversity' WebTAG category.

The present value ranges from a loss of £16.6 to £35.8 million, depending on the scenario. The main component of the value is the land loss classified as "urban core", which has a high value according to the supplementary guidance. Once again, we note that when the effect is in one direction only (i.e. negative in this case), and the loss is constant over time, the scenario "PV100 Health" leads to twice the present value of the scenario "PV60 STPR".

In this calculation the habitat loss is calculated for the area of land lost under the footprint of the scheme. It does not use the Supplementary Guidance on Landscape, which recommends considering 25 hectares on either side of each km of the scheme as "lost", an approach illustrated in Section 2. This means the values identified underestimate impacts.

Table 3.11 A3 case study – a "bundle" approach[27]

<table>
<tr><th>Land Impacted</th><th>ha</th><th>Land Type</th><th>PV60 STPR</th><th>PV100 STPR</th><th>PV60 Health</th><th>PV100 Health</th></tr>
<tr><td>Forestry</td><td>-24.9</td><td>Urban Fringe (forested land)</td><td>-£2.77 m</td><td>-£3.28 m</td><td>-£4.27 m</td><td>-£5.96 m</td></tr>
<tr><td>Exchange Land</td><td>-11.8</td><td>Agricultural Land (extensive)</td><td>-£1.53 m</td><td>-£1.81 m</td><td>-£2.36 m</td><td>-£3.29 m</td></tr>
<tr><td>Agricultural</td><td>-6.9</td><td>Agricultural Land (intensive)</td><td>-£0.03 m</td><td>-£0.03 m</td><td>-£0.05 m</td><td>-£0.06 m</td></tr>
<tr><td>Residential</td><td>-1.4</td><td rowspan="3">Urban core</td><td rowspan="3">-£12. m</td><td rowspan="3">-£14.23 m</td><td rowspan="3">-£18.53 m</td><td rowspan="3">-£25.83 m</td></tr>
<tr><td>Commercial</td><td>-0.7</td></tr>
<tr><td>School Grounds</td><td>-3.3</td></tr>
<tr><td>Public open space</td><td>-8.1</td><td>Urban Fringe (greenbelt)</td><td>-£0.3 m</td><td>-£0.35 m</td><td>-£0.46 m</td><td>-£0.64 m</td></tr>
<tr><td></td><td>-43.6</td><td>Total loss</td><td>-£16.62 m</td><td>-£19.71 m</td><td>-£25.66 m</td><td>-£35.78 m</td></tr>
</table>

The results of the appraisals tested on the A3 are shown in Table 2.12.

[27] The values per hectare per year are taken from Box 2.3
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/627487/value-for-money-supplementary-guidance-on-landscape.pdf

Table 2.12. A3 Appraisal Comparisons.

A3				
(£ m)	PV60 STPR	PV100 STPR	PV60 Health	PV100 Health
Aesthetics	-0.4	-0.4	-0.4	-0.4
Air Quality	-2.6	-3	-3.9	-5.4
Recreation	The change due to the scheme is not estimated, but potentially in the order of magnitude of £millions			
Carbon	-0.4	-0.4	-0.4	-0.4
Total	**-3.4**	**-3.8**	**-4.7**	**-7.2**
Supplementary Guidance (partial)	-16.6	-19.7	-25.7	-35.8
Supplementary Guidance (full)	NA	NA	NA	NA

4 Great Western Main Line Electrification: Reading to Didcot

The electrification of the Great Western Main Line Electrification(GWME) stretches from Maidenhead to Cardiff, an important route connecting the east and west of the United Kingdom. This case study focuses on the electrification of the section between Reading and Didcot. The benefits of electrification included reduced capital costs, reduced journey times, accommodating more passengers, and environmental benefits such as reduced carbon emissions.

Electrification entails the installation of 25kV AC overhead line electrification (OLE) conductor wires supported on gantries spaced between 50m and 66m apart. Network Rail have a vegetation management policy in place that requires vegetation to be removed to a distance of 6.6m either side of the track during construction and operation. This management policy also extends to the removal of vegetation with high leaf fall as leaves on the line reduce grip on the tracks which may lead to delays once the line is operational.

Environmental mitigation strategies have been incorporated into the design of the GWME electrification to minimise the potential environmental impacts during construction and operation. This includes strategic placement of OLE masts, minimising the damage to significant historic structures and designing new structures to ensure they respect the setting of designated assets.

4.1 Landscape aesthetics

The adverse visual impact is given mainly by the construction of OLE gantries every 50 to 66 meters. The visual amenity of the landscape is negatively affected, in particular where there are more open habitats and where there is limited screening of the track. The Environmental Statement divides the Scheme in segments and assigns a level of impact to each of them (e.g. moderate or adverse), as well as analysing the impact for receptors.

Unlike the A3 and A14 case studies, in the GWME case there is no data about the number of properties that experience negative visual impacts - the evaluation of impact on visual amenity of landscape is qualitative. It is noted that the infrastructure route passes through an AONB and therefore visual amenity of landscape could be a significant factor in property values around the scheme. Part of the AONB's character is open downland and valley landscapes, across which views of rural countryside can be extensive. In this context, the application of simple distance rules to identify landscape impacts (e.g. of up to 500m either side of the scheme) would be inadequate. Viewshed functions in GIS are available and should be systematically applied in schemes where impacts of visual amenity of landscape is considered a significant issue[28].

[28] For a scheme that upgrades existing infrastructure (as with OLE on an existing rail line) viewshed calculations should take into account the elevation of individual features in the landscape (e.g. height of overhead lines or vehicles, lines of trees and size of buildings etc) to give an accurate estimation of viewshed. This analysis should be done to inform the qualitative landscape appraisal of schemes in the main WebTAG process, so should be available to inform use of supplementary guidance.

4.2 Air quality

Table 4.1 compares the valuation evidence proposed for this impact category with the relevant information on the good, the change and the affected population from the case study documentation. It shows good comparability between the case study and valuation evidence for the good, change and beneficiaries. Therefore, there is strong evidence for using Jones et al (2017) values.

Table 4.1 GWML case study – Air quality valuation evidence

	Case study	Valuation evidence
The good	Air quality regulation from vegetation	Indicative values of air pollutant removal by vegetation derived from modelling by Jones et al (2017)
The change	Change in health impacts of air pollution following change in pollutant removal due to habitat loss and gain	Avoided health benefits due to pollution removal (respiratory hospital admissions, cardiovascular hospital admissions, loss of life years, deaths)
The beneficiaries	Residents and visitors around the scheme	Applies across the UK population

In order to facilitate construction and safe operation of the Scheme, adjacent vegetation needs to be cleared. All woody plants that are located within 6.6m on both sides of the track are removed during construction and are not allowed to grow back as part of maintenance of the infrastructure. The standard maintenance clearance distance is 3.5m from the outside rail so this additional vegetation clearance of 3.1m would be as a result of the OLE –along the entire route of the Scheme.

From our GIS calculation we estimate that the Scheme is 28.1 km long between Reading and Didcot. Given the extra 3.1m of clearance on each side, the total hectares affected are approximately 17.44[29]. Transport scheme appraisals can use the Land Cover Map (LCM) produced by CEH[30] and purchased by DfT to inform landscape assessment, to determine the habitat types subject to this clearance. An illustrative assumption was made to facilitate this case study using data and qualitative information contained in the Environmental Statement to determine the land cover composition. From the satellite images it appears that the great majority of the area needed to be cleared contained vegetation. Therefore, as a rough estimate, we consider 80% of the clearance to affect woodland. For the remaining 20%, we assumed that no clearance was needed.

Moreover, we used GIS to determine if the clearance was affecting urban or non-urban areas. All the clearance on the sides of the railway was within 20 meters of a building, it was considered to be in an urban area. Using these assumptions suggests 10.1 km out of 28.1 km belonged to urban areas according to this criterion. As a result, 5 hectares of woodland in urban areas and nearly 9 hectares of woodland in non-urban areas were lost. This assignment of areas to urban/rural has

[29] 28,120*6.2/10,000=17.44

[30] https://www.ceh.ac.uk/services/land-cover-map-2015 This process is already applied in the appraisal of HS2.

significant uncertainty, for example because railways or other transport infrastructure may sometimes form the boundary of an urban area.

The woodland loss is valued using indicative values for air quality regulation by vegetation from Jones et al (2017) as discussed in Section 1.2.3.

The present values range from £6.4 million to £13.4 million. Lower discount rates and a longer time horizon lead to a greater air quality regulation loss due to the loss of woodland. The values involved equate to around £0.2 - £0.5 million per km of the route. These costs may not be material to the overall delivery of the scheme, but are considered significant in the context of mitigation and compensation actions.

Table 4.2 GWME case study - Summary of monetized air quality regulation

Output Table - Total present value (baseline 2017)			
Discount rates as per 1.2.7		STPR	Health
		AQ loss	AQ loss
PV60	Woodland -Urban	-£5.51 m	-£8.4 m
	Woodland - non urban	-£0.85 m	-£1.29 m
	Total	-£6.36 m	-£9.69 m
PV100	Woodland -Urban	-£6.5 m	-£11.63 m
	Woodland - non urban	-£1. m	-£1.79 m
	Total	-£7.49 m	-£13.42 m

4.3 Carbon

Table 4.3 compares the valuation evidence proposed for this impact category with the relevant information on the good, the change and the affected population from the case study documentation. It shows good comparability between the case study and valuation evidence for the good, change and beneficiaries. Therefore, there is a strong basis for using this evidence.

As per Section 4.2, 13.95 hectares of woodland are permanently lost. A summary of the valuation of lost carbon storage is given in Table 4.44. The net present value ranges from a loss of £290k to £869k, depending on the specifications used. Similar to the A3 Case study, we note that, due to only negative impacts being identified, and an increasing carbon price over time, the scenario "PV100 Health" leads to more than three times the present value of the scenario "PV60 STPR". However, it is still a negligible value compared to the costs and benefits of a large Scheme.

Table 4.3 GWME case study – Carbon sequestration valuation evidence

	Case study	Valuation evidence
The good	Carbon sequestration from woodland	Carbon sequestration & non-traded carbon value from BEIS guidance
The change	Change in volume of carbon sequestered and stored, based on hectares of woodland loss and gain	Non-traded carbon price based on estimates of the abatement costs that will need to be incurred in order to meet specific emissions reduction targets
The beneficiaries	World population	World population

Table 4.4 GWME case study – monetized carbon sequestration

Output table (2017 £M)			
Discount rates		STPR	Health
PV60	CS Loss	-£0.29 m	-£0.52 m
	CS Gain	£. m	£. m
PV100	CS Loss	-£0.4 m	-£0.87 m
	CS Gain	£. m	£. m

4.4 Noise regulation by vegetation

The Environmental Statement provides extensive details about the adverse noise impact during the construction phase, which are excluded from the case study for being temporary. Regarding the operational phase, it is reported that there would be no adverse noise impacts from the Scheme.

This conclusion suggests that the noise increase due to the extra vegetation clearance of 3.1 meters is outweighed by electric trains being about 3dB quieter than the diesel equivalents. This assumption is supported by noise regulation modelling in the UK Urban Natural Capital account (eftec et al, 2017) which assumed a minimum area of tree canopy of 200m^2 is necessary to achieve a 2dB reduction in traffic noise.

4.5 Following the “Supplementary Guidance on Landscape”

Table 4.5 summarises the monetised value of the land loss using the current Supplementary VfM Guidance on Landscape values (DfT 2016). The permanent land loss data is obtained from the calculation outlined in Section 4.2 and corresponds to the column “Land impacted”, which is about 5 hectares of urban woodland and 9 hectares of rural woodland. These land types are matched to the categories used in the main supplementary landscape guidance. However, there isn’t a good match between the land types in the supplementary guidance and the habitats impacted.

The land type ‘rural forested land (amenity)’ is used, as this is arguably the closest match to the rural woodland area identified. This rural woodland has amenity in the sense that it provides a range of benefits, such as visual screening. However, the amenity value of most rural woodland/forests is closely related to recreational value, and this is not relevant to lineside vegetation (which will not have public access). Therefore, other land types, such as 'natural and semi-natural land', which do not have an explicit amenity function, are arguably a better match to the lineside woodland.

A similar issue with lack of accessibility also applies for the area of urban woodland impacted.

The present value ranges from a loss of £2.4 to £5.1 million, depending on the scenario. Once again, we note that when the effects are in one direction (here, negative) and the loss is constant over time, the scenario "PV100 Health" leads to twice the present value of the scenario "PV60 STPR".

Table 4.5 GWME case study – a "bundle" approach

Land Impacted	ha	Land Type	PV60 STPR	PV100 STPR	PV60 Health	PV100 Health
Woodland urban	-8.98	Urban Fringe (forested land)	-£0.997 m	-£1.183 m	-£1.54 m	-£2.147 m
Woodland rural	-4.97	Rural forested land (amenity)	-£1.356 m	-£1.607 m	-£2.093 m	-£2.918 m
	-13.95	Total loss	-£2.353 m	-£2.79 m	-£3.633 m	-£5.065 m

Similar to the factors discussed in Section 3.5, the habitat loss identified under the footprint of the scheme is an underestimation of total impacts. This is because this case study only looks at land that is lost due to the footprint of the scheme (i.e. the vegetation clearance). Conversely, the Supplementary Guidance on Landscape recommends to considering land as impacted up to 25 hectares on either side of the proposed scheme for each km (which is 250 meters on each side).

The Supplementary Guidance has not been fully implemented in this case study due to lack of information in the appraisal documents examined for the research. Specifically, evidence was lacking on the land cover in the areas around the transport schemes, or on which land use types were identified to assign values from the supplementary VfM guidance. However, it is worth nothing that the estimated value of impacts would increase dramatically. Just as a theoretical example, if we assume a 100% damage for further 250 meters on each side (as recommended in the supplementary guidance), and the land cover to be the same (e.g. rural woodland), the total loss would be in a range of £190 - 408 million., an increase by a factor of 81[31],

However, the 25ha distance rule is unsatisfactory for some of the impacts considered in this case study. A distance from the scheme of 250m is clearly unsatisfactory to capture all the visual amenity impacts on property (described in Section 4.1) and on recreation. For recreation, the views of the scheme could affect the recreational value of schemes within the viewshed of the scheme (i.e. from which you could see the OLE). Viewshed in an open landscape can capture an area several kms from the scheme.

[31] The current methodology considers the clearance of 3.1 meters on each side. Assuming 250 meters of loss we need to multiply by 250/3.1=80.7

The results of the appraisals tested for the GWME are shown in Table 4.6.

Table 4.6. GWME Case Study Summary.

GWME				
(£ m)	PV60 STPR	PV100 STPR	PV60 Health	PV100 Health
Aesthetics	NA	NA	NA	NA
Air Quality	-6.4	-7.5	-9.7	-13.4
Recreation	The change due to the scheme is not estimated, but potentially in the order of magnitude of £millions			
Carbon	-0.3	-0.4	-0.5	-0.9
Total	**-6.7**	**-7.9**	**-10.2**	**-14.3**
Supplementary Guidance (partial)	-2.4	-2.8	-3.6	-5.1
Supplementary Guidance (full)	-189.8	-225	-293	-408.5

5 Conclusions

This report applies the methods suggested in the Methodology Report (5th March 2018) to three case studies. Although the analysis has been partly hindered due to data limitations, there are several lessons learned regarding the proposed appraisal methods. This evidence will be reflected in the final project report to help DfT develop new guidance for evaluation of landscape impacts of transport interventions.

5.1 Appraisal methods

The suggested appraisal methods performed very differently in terms of uncertainty and in matching the available data:

5.1.1 Landscape aesthetics

Applying the Mourato et al (2010) value used for landscape aesthetics, which was already uncertain and subject to many assumptions from the original paper, added further uncertainty. The change in visual effects recorded by the case studies did not match the change valued by Mourato et al. For example, the different levels and interpretations of the qualitative assessment of schemes did not match the change analysed by Mourato et al (i.e. how to differentiate between large adverse and moderate adverse visual effects?). Overall, there are large uncertainties around using this value.

5.1.2 Air quality

The air quality valuation using indicative values from Jones et al (2017) was relatively straightforward to apply to areas of vegetation impacted by the schemes. However, the high degree of uncertainty of the values, which are based on interpolation from models of air pollutant removal by vegetation, needs to be overcome with further research. This can produce a look-up table of the estimate the value of air quality regulation in different land types and parts of the UK.

5.1.3 Noise

The valuation of noise regulation by vegetation could not be tested through these case studies. This was due to a lack of data required in modelling of the noise mitigating effects of vegetation – which requires detailed data on noise sources, tree canopy extent and properties, applied at a fine spatial scale (eftec et al, 2017). For instance, data on noise decrease due to noise mitigation measures and number of properties affected.

The electrification case study gave an interesting comparison between the scale of noise mitigation by vegetation that is valued in the UK natural capital accounts (2dB) and the reduction in noise from the electrification (3dB). Taking into account the loss of noise mitigation due to vegetation removal it could result in the net impact of the scheme on a property being a reduction of 1dB rather than 3dB.

5.1.4 Carbon

The appraisal of the carbon storage is well-established for some UK habitats and the values used are spatially insensitive. The carbon storage can be valued using the non-traded carbon value from BEIS guidance (2013). Therefore, changes to carbon sequestration capacity of vegetation can be readily valued based on the habitat changes in the case studies. Overall, we note that the value of carbon storage is relatively low. For example, they are lower than the impacts of losing vegetation in relation to air quality regulation.

5.1.5 Recreation

Recreational areas and footpaths directly affected by schemes (i.e. lost or created) can be identified and valued using the ORVal tool. The indirect effects on recreation are more problematic. Accessible areas or footpaths affected can be identified, and their total value for recreation estimated using ORVal. However, there are two major uncertainties in applying this evidence in appraisal:

- The distance from schemes over which recreational sites are indirectly affected is uncertain. Sites within a scheme's viewshed, which can be several km, might be affected, whereas the supplementary guidance limits the impacted area to within 250 or 500m of a scheme. In addition, the appropriate distance varies with the different types of impacts (e.g. visual amenity or noise).
- The proportion of a site's value is lost due to the indirect effects is uncertain. This might be estimated based on expert judgement, but will have high uncertainty unless supported by further research.

5.1.6 Compensation

There are mitigation measures in place at several of the case studies, including new recreational areas around the A14, and habitat restoration around the A3. The assessment of these aspects of the case studies will be continued in relation to Task 3.1 of the project – which is investigating mitigation measures and ecosystem service markets.

5.2 Appraisal assumptions

One of the objectives of the case studies was to test different combinations of discount rates and time horizons and understand the sensitivity of results. We tested two combination of declining discount rates, "STPR" and "Health", with the latter using lower discount rates. We tested them against two time horizons: 60 or 100 years. Therefore, we have four sets of assumptions: PV60 STPR, PV100 STPR, PV60 Health, and PV100 Health.

As expected, higher discount rates and shorter time horizons have the effect of reducing the present value. More precisely, it is almost always true (except A3 landscape aesthetics) that:

- PV60 STPR < PV100 STPR < PV60 Health < PV100 Health if there are positive values to be discounted
- Vice versa if there are negative values

Hence, we note that choosing "Health" discount rates instead of the "STPR" affects the present value more than changing the time horizon from 60 to 100 years.

Furthermore, we note that, if the impacts only occur in one direction (i.e. either only negative or only positive), and the effects are constant over time, the scenario PV100 Health will produce a present value about twice the PV60 STPR. When the impacts are not constant over time, the ratio between the two scenarios is unpredictable. For instance, in the A3 carbon sequestration, PV100 Health produces a present value over three times the PV60 STPR, as the price of carbon increases over time.

Further unpredictability is added when there is a variable time profile of benefits and negative impacts. If the time profile is asymmetrical, e.g. all the damages occurring in the near future and most of the benefits occurring in the long term, present values change significantly with different assumptions about discount rate and time horizon. More specifically, low discount rates and longer time horizon give more "weight" to distant impacts.

Overall, given the variety of size, direction and timing of the impacts from transport schemes, appraisal results are likely to be sensitive to assumptions on timescales and discount rates, and this can change the net impacts of a scheme on a particular benefit (e.g. visual amenity) between positive and negative, or vice versa.

5.3 Comparison of the new valuation versus the current guideline

The case studies have demonstrated valuation of a range of ecosystem service, with varying levels of uncertainty. Bearing in mind these uncertainties, it is possible to aggregate the valuation of different services and compare this sum with the result of applying the Supplementary Guidance on Landscape. This comparison is summarised in Table 5.1.

5.3.1 A14 Case study

The sum of the ecosystem service valuations gives a total cost of £1.2 million under the PV60 STPR scenario and £6.1 million under PV100 Health. Hence, it is not clear if the Scheme leads to a net benefit overall. Under PV100 Health assumptions both the current guideline (partial) and the sum of ecosystem service valuations gives a net benefit of £ 6.1 million, which should not be interpreted as convergence of methods.

This case study highlights the importance of the discount rates used. In fact, for both the valuation of landscape aesthetics and air quality, the sign of the present value changes depending on the discount rate used, but not on the time horizon. This happened because most of the negative impacts occur in the near future, and the benefits further in the future. Low discount rates give more weight to the distant benefits and as a result the present value becomes positive.

5.3.2 A3 case study

The sum of the ecosystem service values shows a cost ranging from £3.4 million under PV60 STPR to £7.2 million under PV100 Health. The loss of air quality regulation service due to lost vegetation is the largest contributor to this cost.

The Supplementary Guidance has been applied only partially based on the data on the actual footprint alone. This application leads to a cost estimate ranging from £16.6 to £35.8 million depending on the scenario.

Thus, implementing (partially) the Supplementary Guidance leads to an impact 5 times higher than using the ecosystem service valuations. This difference is mainly given the component of land lost classified as "urban core", which is assigned a very high value in the Supplementary Guidance.

5.3.3 GWME Case Study

The sum of the ecosystem service values shows a cost ranging from £6.7 million to £14.3 million under PV60 STPR and PV100 Health, respectively. Again, the loss of air quality regulation service due to lost vegetation is the largest contribution to this cost.

Applying the Supplementary Guidance led to lower cost estimates (£2.4 to £5.1 million) when applied partially (to the footprint of the scheme). This is about 3 times less than the ecosystem service valuation, but of a similar order of magnitude. When the Supplementary Guidance is applied in full, the cost estimates are significantly higher at £-189.8 to £-408.5 million. The reason for this is that full application assumes the landscape loss extends for further 250 meters on each side of the Scheme, along its 28 Km of length. Furthermore, the land cover data was not available and therefore we assumed the land adjacent was rural woodland. Although not a precise estimation, this shows the potential sensitivity of these appraisals to assumptions about the distance from the infrastructure over which impacts arise.

The lineside habitat vegetation cleared as part of the scheme does not align to any of the land type categories in the WebTAG supplementary guidance. They also illustrate the significant differences in the spatial distribution of scheme impacts – some impacts are restricted to the few meters adjoining the infrastructure (e.g. carbon sequestration), whereas visual amenity can be impacted over a distance of several km.

Table 5.1 Summary of valuations

	A14		A3		GWME	
(£ m)	PV60 STPR	PV100 Health	PV60 STPR	PV100 Health	PV60 STPR	PV100 Health
Aesthetics	-0.3	1.1	-0.4	-0.4	NA	NA
Air Quality	-2.9	1.2	-2.6	-5.4	-6.4	-13.4
Recreation	The change due to the scheme is not estimated, but potentially in the order of magnitude of £millions					
Carbon	1	3.8	-0.4	-1.4	-0.3	-0.9
Total	**-2.2**	**6.1**	**-3.4**	**-7.2**	**-6.7**	**-14.3**
Supplementary Guidance (partial)	2.8	6.1	-16.6	-35.8	-2.4	-5.1
Supplementary Guidance (full)	-1.2	-2.5	NA	NA	-189.8	-408.5

The results in Table 5.1 suggest that the choice of land type is important, and their values in the supplementary guidance vary significantly (see Box 2.3, reproduced below). Comparisons of the ecosystem service and land type values are inconclusive. However, even accounting for the uncertainty involved, the reasons for variations in ecosystem service values do not give confidence in the substantial differences between values for different land types in the supplementary guidance.

The ecosystem services values have significant uncertainties when applied to the case studies. Overall they could not be used to appraise scheme investments either individual, nor if summed into a 'bundled' value. However, some of the valuations (e.g. of air quality, carbon) can be used to unpick the scale and distribution of impacts. For example, they help understand the distances and spatial scale over which schemes have effects, and identify winners and losers. In the case studies, analysis identified some groups which will experience negative impacts from schemes, even though the appraisal of landscape effects gives overall positive outcomes. They thus provide potentially important evidence on the distribution of impacts to help with mitigation design/ actions for schemes, in a way that bundled values in the Supplementary Guidance do not.

Box 2.3: Landscape values for different landscapes

Land Type	Value per hectare Per year(£)	Present Value per hectare (£) (2010 prices, infinite period)	Comments
Urban core	75,153	15,031,000	Central urban area. Examples include public spaces and city park.
Urban Fringe (greenbelt)	1,237	247,000	Areas of transition where urban areas meet countryside.
Urban Fringe (forested land)	3,758	752,000	Forested land on urban fringes, more valuable than typical urban fringe.
Rural forested land (amenity)	9,222	1,844,000	This value represents the range of forests in the UK, including both commercial and amenity forests.
Agricultural Land (extensive)	4,384	877,000	Areas of rough grassland where extensive agricultural practices such as sheep farming dominate. May include farm buildings forming part of the agricultural holdings.
Agricultural Land (intensive)	143	29,000	This type of land is usually in farmland under intensive agriculture (usually land under food production). May include farm buildings forming a part of the agricultural holdings.
Natural and semi-natural land	9,208	1,842,000	This includes uncultivated areas, wetlands and areas with nature conservation designations.